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AND

NATIONAL PROGRESS

ESSAYS AND ADDRESSES

1870–1905

BY

SIR NORMAN LOCKYER, K.C.B.

WITH AN INTRODUCTION BY THE RIGHT HONOURABLE

R. B. HALDANE, K.C., M.P.

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INTRODUCTION.

BY

THE RIGHT HONOURABLE R. B. HALDANE, M.P.

With the thesis which forms the text of this collection of Essays and Addresses I am wholly in agreement. What we most lack in this country is the penetration of the mass of our people by the spirit of the Higher Education. Alike in our peace and in our war organisations there is wanting the survey based on science. Without this survey, and the grasp which it yields of the relative proportion of things, a vast waste of matter and energy alike is inevitable. As a nation we possess great qualities. Individuality, initiative, courage, are distinctive of our people. We are well fitted to hold our own in the race for supremacy. But we handicap ourselves by want of the higher training. Such training requires self-submission to hard intellectual discipline, and it is in this self-submission that the majority of our young men are lacking.

None the less progress is being made, and being made rapidly. The standard of knowledge is rising, and I

think that with it the moral standard is rising. Our people are becoming more temperate, and they are insisting on a higher standard of living. They will go further, so the evidence seems to indicate, if they are well led.

For the training of the necessary leaders the Higher Education is essential, and the Universities are its only reliable source. One of the satisfactory features of our time is the large increase in the number of our Universities within the last ten years, and the generous endowment of them from private sources. That the State ought to do more than it does in the way of endowment I agree with the writer of this book. But I am not sure that I wish to see the burden transferred to the State in the wholesale fashion that is sometimes suggested. In expenditure out of taxes science is as essential as in the arts and crafts to which these Essays and Addresses refer. Probably nothing conduces more to national efficiency than frugality in the use of national resources. The private donor should be encouraged and not left to expend his generosity in regions which do not concern the State directly. In writing this I do not mean that the Government ought not to spend public money generously upon the Universities. I mean that it should not be spent unless and until a case for the necessity of such expenditure has been clearly made out.

There has been too much waste in the past over some matters connected with education, and, as the result, too much starvation over others, to make this warning superfluous. No one who has had to do with the business of Government can fail to have felt the pang of regret at the discovery that precipitate expenditure in the past, which events have shown to be misplaced, has deprived him of the money necessary to effect necessary reforms. *Festina lente* is a good maxim for a Chancellor of the Exchequer. He must remember both the words of the maxim.

With this preliminary word of caution I associate myself enthusiastically with the endeavour of my colleague in the British Science Guild. There is a saying of a recent writer which I will quote as expressing the pith and marrow of what Sir Norman Lockyer and others of us desire to preach as our gospel:—"Vom Wissen Zu Können ist immer ein Sprung; der Sprung aber ist vom Wissen und nicht vom Nicht-Wissen."

R. B. HALDANE.

PREFACE.

I have brought together in the present volume several among my Essays and Addresses on educational subjects which have appeared during the last thirty-five years.

In these I endeavoured to show how vital it is, from a national point of view, that the education of everybody, from prince to peasant, should be based upon a study of things and causes and effects as well as of words, and that no training of the mind is complete which does not make it capable of following and taking advantage of the workings of natural law which dominate all human activities.

My point has in all cases been that the nation most highly educated in this manner can, if the number of combatants be equal, best hold its own in the struggle for existence both in peace and war, seeing that success in either now depends not upon muscle but upon the utilisation of the best and most numerous applications of science. If the number of combatants is unequal, then the smaller number can only hold its own if it be much more highly educated than its opponent.

The present position of Britain from this point of view shows that those of us who have endeavoured for the last thirty-five years to point out the way in which our people can survive in the struggle, have, to a large extent, been crying in the wilderness. In spite of what

has been done during the last ten years, instead of a relative advance there is still a relative decline in relation to other countries. The United States and Germany now have greater populations than ourselves and at the same time the best and most complete education, science and research, are there fully fostered, while they are practically left uncared for by the British Government.

If this goes on there can only be one result, which cannot be evaded even by the close welding together, be it sympathetic, fiscal or political, of all the British people beyond the seas, unless the greater population is at the same time furnished with greater brain-power than that of the competing nations.

This will not be until the British and Colonial Governments change their attitude towards science and the higher instruction. Largely increased endowments of the higher education and research, and the utilisation of scientific methods in all branches of the administration, equal to those at the disposal of competing nations, can alone save us.

Strenuous efforts should be made to apply these remedies at once; if delayed they may be too late.

I have to thank Mr. Haldane, who among other things is the President of the Science Guild, for the honour he has done the book by writing an introduction.

NORMAN LOCKYER.

November, 1906.

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EDUCATION AND WAR.

(1870.)

The dogs of war are again let loose, and in the two most highly civilised countries of Europe, where, a little time ago, science, education and commerce were in full sway, all the arts of peace are already neglected, and in prospect have gone back a quarter of a century. We can hardly yet realise that at the present moment railways are being torn up, lighthouses dismantled, lightships towed into harbour, and monuments of engineering skill, such as the bridge over the Rhine at Kiel, undermined, so that they may be destroyed at a moment's notice. But these, after all, are calamities of the second order; education is stopped; science schools are broken up; both professors and pupils are forsaking the laboratory and the class-room, and the whole machinery of progress has come to a standstill.

Science has little to do with politics: the function of science is to unite the whole human family, whereas the function of politics seems to be, both in the case of men and nations, to create parties and to emphasise them as much as possible, the object in each case being place for the partisans—whether that place be an income of

a few thousands a year in one case or increased territory in the other.

As science advances such policies will be overridden—when science and education have taken their proper position—when the sword has given place to brain—when more of the best men of each nation take part in each nation's counsels, the dreadful thirst after blood will give way to something better; monarchs will see the folly of being surrounded merely with empty helmets, or at all events if they do not, others will; and much will have been done when the pampering of armed men shall cease.

There is one point, however, in connection with the coming war which cannot be pointed out too strongly—one duty which England owes to herself, and which, if it be well done, may make her after all a gainer from the dreadful strife. It has been already stated, and the statement is not an exaggeration, that the war will throw the countries engaged in it back a quarter of a century. Now, England at the present moment, be the cause what it may, is in many things a quarter of a century behind France and Prussia, notably in education of all kinds and especially in scientific education.

The following extract from the Report of Mr. Samuelson's Committee on Scientific Education—a report which, we believe, has not even yet been taken into consideration by our Legislature—is so much to the point that we give it here :—

"Nearly every witness speaks of the extraordinarily rapid progress of Continental nations in manufactures, and attributes that rapidity, not to the model workshops which are met with in some foreign countries, and are but an indifferent substitute for our own great factories, and for those which are rising up in every part of the

Continent; but, besides other causes, to the scientific training of the proprietors and managers in France, Switzerland, Belgium and Germany, and to the elementary instruction which is universal amongst the working population of Germany and Switzerland. There can be no doubt, from the evidence of Mr. Mundella, of Professor Fleeming Jenkin, of Mr. Kitson and others, and from the numerous reports of competent observers, that the facilities for acquiring a knowledge of theoretical and applied science are incomparably greater on the Continent than in this country, and that such knowledge is based on an advanced state of secondary education.

"All the witnesses concur in desiring similar advantages of education for this country, and are satisfied that nothing more is required, and that nothing less will suffice, in order that we may retain the position which we now hold in the van of all industrial nations. All are of opinion that it is of incalculable importance economically that our manufacturers and managers should be thoroughly instructed in the principles of their arts.

"They are convinced that a knowledge of the principles of science on the part of those who occupy the higher industrial ranks, and the possession of elementary instruction by those who hold subordinate positions, would tend to promote industrial progress by stimulating improvement, preventing costly and unphilosophical attempts at impossible inventions, diminishing waste and obviating in a great measure ignorant opposition to salutary changes.

"Whilst all the witnesses concurred in believing that the economical necessity for general and scientific education is not yet fully realised by the country, some of them consider it essential that the Government should interfere much more actively than it has done hitherto, to promote the establishment of scientific schools and colleges in our great industrial centres."

It is impossible that we can say anything stronger than this in favour of taking the fullest advantage of the opportunity of regaining our intellectual and therefore our commercial prestige.

If England is to prepare for war, the abnormal condition, so let it be; but surely, *à fortiori* she should *prepare for peace*, the normal one, as well. This has never struck her ministers, and the reason is not far to seek.

But this is not all; the same disregard for science,

arising from the ignorance of science among our rulers, has probably placed us in another position of disadvantage. While France and Prussia have been organising elaborate systems of scientific training for their armies, a recent Commission has destroyed what little chance there was of our officers being scientifically educated at all. As there is little doubt that a scientific training for the young officer means large capabilities for combination and administration when that officer comes to command, we must not be surprised if the organisation of our army, if it is to do its work with the minimum of science, will, at some future time, again break down as effectually as it did in the Crimea, or that our troops will find themselves over-matched should the time ever come when they will be matched with a foe who knows how to profit to the utmost from scientific aids.

While, therefore, the Continent is being deluged with blood, let us *prepare for peace* as well as for war; let us prepare ourselves for victories in the arts, conquests over nature; let us, by means of a greater educational effort, more science schools, a truer idea of the mode in which a nation can really progress, fit ourselves to take our place among the nations when peace returns. Surely if there be statesmen among us, such a clear line of policy will not be overlooked.

Education and Science at the present moment are England's greatest needs.

THE ENDOWMENT OF RESEARCH.

(1873.)

There are not wanting signs that ere long the whole question of the present condition of research in this country, and of its amelioration, will undergo a complete discussion. Those who are best acquainted with this condition, and the position occupied by England at the present moment in the science of the world, will be the first to acknowledge the importance of general attention being directed to the subject.

When the matter comes to be considered by minds free from the trammels alike of tradition and of prejudice, it will doubtless be found strange that such a fundamental question should have waited so long before it should have asserted itself; on the other hand, it is perfectly clear that many who are even now considering it have utterly failed to grasp it as it will have to be grasped.

This lack of clearness in the appreciation of the vast bearings of the question is quite pardonable, and is, doubtless, to a large extent, the natural consequence of the manner in which physical science has been added to the older knowledge. It would seem, however, that a mere statement of a few fundamental positions should clear the view. These positions, most fortunately, are rapidly asserting themselves.

First, we have the generally acknowledged fact that a nation's progress depends upon its science. Science, in fact, is the engine which must be as ever active in peace as the cannon's mouth is in war, and a nation may just as safely neglect one as the other.

This brings us to the second position. Does England as a nation pay as much heed to the one as the other? or as much as other nations? To ask this question is to answer it. England as a nation does next to nothing for this peace armament, and on all hands it is acknowledged that the nation's progress from this point of view is in great danger, because the decline of research in England, not only relatively, but absolutely, is so decided, that it is already a matter of history.

To what then is this decline to be attributed? The reply to this question brings us to the third point. There is absolutely no career for the student of science, as such, in this country. True scientific research is absolutely unencouraged and unpaid. The original investigator is of course the man here intended, not the man who turns science into a means of livelihood, however honourable, either as a teacher or a manufacturer.

There can be no doubt that to this state of things our present condition is to be ascribed, and this point is, according to us, the key of the whole position. A glance at the condition of things in France and Germany will strengthen our view. Why was Germany till lately the acknowledged leader in all matters connected with the advancement of knowledge? Because there were no such brilliant and highly paid careers open there as here to those who choose politics, the bench, the bar or commerce, in preference to science. And what is happening

there at present? A decline visible not alone to the far-sighted, because Germany is getting rich just as England has long been rich. Why is France now endowing research on a large scale, and even proposing that the most successful students in her magnificent Polytechnic School should be allowed to advance Science as State servants? Because in France there is a Government instructed enough to acknowledge that a decline of investigation may bring evil to the State, and that it is the duty of the State to guard against this condition of things at all cost, this condition till lately, there as here, being that outside of the State service and outside of the professoriate, no means of existence are provided for a student of science; hence men of the most excellent promise are yearly lost to research, which undoubtedly also is the case with us.

What course does it then behove us to pursue in this country, in order that science may take up its true position in our midst? in the middle.

Here again opinion is rapidly forming itself. It is obvious to all who have thought about the matter, that it is absolutely indispensable that an employment, necessary for the public good, which is neglected to the State's detriment because in itself it does not bring in a livelihood, should be artificially supported at the public expense. It would be quite justifiable, both from an economical and also a political point of view, to provide for the needs of knowledge out of the taxation of the country; because the taxpayer gets back his *quid pro quo* for the taxes he pays in the form of the amelioration of the conditions of living, as he gets it back in the form of security and good government.

It will probably be a considerable time before this truth is brought home to the public mind so completely as to render possible any large grant of national income for this purpose; but there are not wanting indications that statesmen of all parties are awakening to its reality, which in point of fact has long been conceded in principle. Still, such a source of support for science to any very large extent must appear, even to the most sanguine, a thing of the future.

confident

The area of knowledge will probably, in the future, increase beyond the means of any artificial support less than the national one; but perhaps it cannot be said that this state of things exists at present.

What, then, are we to do in the meantime? Have we no means which are at hand and immediately available, which may suffice to support the present claims of knowledge, without drawing too extensively upon the long-suffering or the intelligence of the taxpayer?

We have the means, if we will only employ them—nay more, some of them are now, for the most part, lying idle—of not only supplying all the needs of the physical and other sciences, but of supplying them magnificently. To mention no other sources of supply, there is the Patent Fund, and the endowments of the colleges of the old Universities.

As to the Patent Fund, it is not too much to say that a large part has been derived from the application of the abstract truths of physical science to the requirements of ordinary life, and that therefore the needs of physical science would be properly provided for out of it.

As to the College Endowments, whichever way we look

at them, either as private bequests, as they are at length ceasing to be regarded, or as public funds, the conclusion is the same: their proper destination is the support of learning and science.

If we look upon them as private bequests, and interpret the wills of founders and benefactors on the usual *çi-près* principle, we should be right in devoting to investigation of facts at first hand the funds which were left by the far-seeing men of the time of the revival of letters for the support of book-learning, which at that time occupied the place of modern science. That they so regarded the aim of these bequests is shown, amongst other things, very remarkably by the universal annexation to the enjoyment of them of the condition of residence within the Universities. When the whole, or the major part, of the materials of investigation was enshrined in libraries, to insist that a man should remain where libraries were, was to insist that he should remain in his workshop.

If, on the other hand, we are to regard these endowments as public funds, as is now generally agreed, is it right that such public funds should be consumed either in educating those who are practically as well able to pay for their own education as those who now receive a similar one at, say, the London University, an institution which is not aided by the State; or in supplying a life-maintenance to a considerable body of able young men, in return for passing a good examination at the outset of life?

It is well known that the ordinary Fellow of a college does not dream for a moment that he has any duties towards knowledge or science. He regards the public

money which he enjoys as a portion in a freehold estate, to enable him to tide over the uncertain years which come at the commencement of the ordinary professional career, the brilliant rewards of which we have shown to be the cause of the decline of science in this country, because they enable the practical life to outbid in attractiveness the laborious, but most necessary, pursuit of truth.

TECHNICAL EDUCATION.

(1877.)

Professor Huxley has seized the occasion offered him by his promise to aid the Working Men's Club and Institute Union by contributing to their present series of fortnightly lectures, to state his opinion on a question which has lately been exercising the minds of some of the most influential members of various city companies.

For some time past a joint committee, representing the most important among these bodies, has been endeavouring to obtain information as to the best means of applying certain of their surplus funds to the assistance of what is called technical education, and there is little doubt that a proposal for a huge technical university, made some time ago, and the discussion which took place in connection with that proposal, has had somewhat to do in leading to the present condition of affairs.

Professor Huxley and some four or five other gentlemen have been appealed to by this joint committee to send in reports on what they consider the best way to set about the work, and it is from this point of view that Professor Huxley's lecture is so important. It was not merely fresh and brilliant and full of good things, as all his lectures are, but is doubtless an embodiment of his report to the joint committee.

We are rejoiced, therefore, to see that Professor Huxley is at one with the view that, after all, the mind is the most important instrument which the handicraftsman, whether he be a tinker or a physicist, will ever be called upon to use, and that a technical education which teaches him to use a lathe, a tool or a loom, before he has learned how to use his mind, is no education at all.

Professor Huxley not only defined technical education as the best training to qualify the pupil for learning technicalities for himself, but he stated what he considered such an education might be, and how the city funds can be best spent in helping it on.

Besides being able to read, write and cipher, the student should have had such training as should have awakened his understanding and given him a real interest in his pursuit. The next requirement referred to was some acquaintance with the elements of physical science —a knowledge (rudimentary, it might be, but good and sound, so far as it went), of the properties and character of natural objects. The professor is also of opinion that it is eminently desirable that he should be able, more or less, to draw. The faculty of drawing, in the highest artistic sense, was, it was conceded, like the gift of poetry, inborn and not acquired; but, as everybody almost could write in some fashion or other, so, for the present purpose, as writing was but a kind of drawing, everybody could more or less be supposed to draw. A further *desideratum* was some ability to read one or two languages besides the student's own, that he might know what neighbouring nations, and those with which we were most mixed up, were doing, and have access to valuable sources of information which

would otherwise be sealed to him. But above all—and this the speaker thought was the most essential condition—the pupil should have kept in all its bloom the freshness and youthfulness of his mind, all the vigour and elasticity proper to that age. Professor Huxley then went on to explain that this freshness and vigour should not have been washed out of the student by the incessant labour and intellectual debauchery often involved in grinding for examinations.

We gather from this part of the address—we shall refer to the others by and by—that so far as Professor Huxley's advice goes we are not likely to see any great expenditure of the money of the ancient city corporations either in the erection of a huge "practical" university or in the creation of still another "Examining Board." How then does he propose to spend it?

Here we come to a substantial proposal which Professor Huxley may consider to be the most important part of his address. What is wanted, he considers, is some machinery for utilising in the public interest special talent and genius brought to light in our schools. "If any Government could find a Watt, a Davy or a Faraday in the market, the bargain would be dirt cheap at 100,000*l*." Referring to his saying when he was a member of the London School Board that he should like to see a ladder by which a child could climb from the gutter to the highest position in the State, he dwelt upon the importance of some system by which any boy of special aptitude should be encouraged to prolong his studies, to join art and science classes, and be apprenticed, with a premium if necessary. In the case of those who showed great fitness for intellectual pursuits they might be trained

as pupil teachers, brought to London, and placed in some collegiate institution or training school. In this way the money of the guilds would be spent in aiding existing teaching systems, in which, on the whole, an enormous progress was acknowledged.

It is true the architects of London would not have the opportunity of immortalising themselves by erecting an imposing edifice, but, on the other hand, the influence of the Guilds might be felt whenever there was a handicraft to foster, or a potential Watt to be sought out.

We do not imagine that it is Professor Huxley's idea that there shall be no local representation of the city's new activity and influence; the reference to the training of teachers, we fancy, and other remarks here and there, seem to point to some such institution as the École Normale of Paris, where the best and most practical scientific teaching could be carried on. Everyone knows how much room there is for such an institution as this, but on this little money need be spent, so far as bricks and mortar are concerned, as little money is needed to equip such laboratories as are really meant for work.

There is an advantage in such lectures as these by no means limited to the expression of opinion on the part of the speaker. The slow and sure way in which science is taking a hold upon our national progress is well evidenced by the fact that the daily press can now no longer ignore such outcomes as these, and hence it is that they do good beyond the mere boundary of the question under discussion. They show the importance of, and foster interest in, the general question of intellectual and scientific progress.

The Times agrees in the main with the kind of

education to be given, and holds that "What is needed is to give a man the intelligence, the knowledge of general principles, combined with the habits of correct observation and quick perception, which will enable him afterwards to master the technicalities of his art, instead of becoming a slave to them. No objection can be taken to the advice that, for this purpose, a lad, after learning to read, write and cipher, should acquire some facility in drawing and should be familiarised with the elements of physical science. The importance of the latter study for this particular purpose is, indeed, unquestionable, and even paramount, for a handicraftsman is dealing exclusively with physical objects in his work, and his skill in applying the processes of his craft will vary in great measure with his knowledge of the scientific principles on which they depend."

But we fancy that *The Times* writer does not look upon this scientific part of education quite as the lecturer does, for he proceeds to add: "There can be little doubt, for instance, that many of the perils of mining might be averted if the miners were alive to the scientific reasons of the precautions they are urged to adopt. Many an improvement, probably, which now escapes the eye of a man who adheres slavishly to the rules of his craft would occur to him if he were applying them with conscious intelligence."

The Times, however, considers that the school-time is too short for the languages and, curiously enough, drives its point home by saying a harder thing about the Greek and Latin of our public schools than Professor Huxley has ever done; while, on the other hand, the *Daily News* points out that Professor Huxley this time

may have raised a hornet's nest about his ears by the unduly reasonable tone of his demands.

The *Daily News* then adds: "A man of science who does not demand that from the earliest age an hour a day shall be devoted to each of the ologies may be regarded as a traitor to his cause." For our part we know of no man of science who has ever made such a demand; and a careful examination of what men of science have said on this point for the last ten years will show that these extreme views to which reference is here made are not those of men of science at all.

It will be well also if the strong language used in connection with the multiple examinations of the present day brings that question well before the bar of public opinion. *The Times* is "sorry to see another flout thus inflicted, in passing, on that system of examinations which, like most good institutions, may do harm to the few, but is indispensable as a motive for work to the great majority." Professor Huxley has expressed the views of most of the leading teachers in this country with regard to the effect of these examinations upon the students, and he might have referred to their reflex action on the examiner. Go into a company of scientific men, and observe the most dogmatic, the most unfruitful and the least modest among them, you will find that this man is, as we may say, an examiner by profession. Speak to him of research or other kindred topics, he will smile at you—his time is far too precious to be wasted in discussing such trivialities; like his examinees, he finds they do not pay. The example set by Germany in this respect, both as regards students and professors, cannot be too often referred to, and there is

little doubt that the love of science for its own sake which has made Germany what she now is intellectually, has sprung to a large extent from the fact that each young student sees those around him spurred from within and not from without. *Noblesse oblige.*

In point of fact, as far as our future scientific progress is concerned the examination question is as important as that connected with the kind of education to be subsidised by the city guilds, and it is important, seeing that our legislators will, in the coming time, have to give their opinion on these subjects as well as on beer, vivisection and contagious diseases, that in Professor Huxley's language,

"By the process called *distillatio per ascensum*—distillation upwards—there should in time be no Member of Parliament who does not know as much of science as a scholar in one of our elementary schools."

THE EDUCATION OF OUR INDUSTRIAL CLASSES.*

(1883.)

It is, I believe, according to precedent, now that another year's work of the Science Classes here has been crowned by the award of prizes, that I should address you on some topic allied to the matters which have brought us together to-night.

I need not search long for a subject, for the scientific education of those engaged in our national industries—upon the success or failure of which, in the struggle for existence, the welfare of our country so largely depends—is now one of the questions of the day.

I propose, therefore, to lay before you some facts and figures bearing upon the education of our industrial classes, and I shall attempt to make what I have to say on that special point clearer, by touching upon some preliminary matters, which will show how it is that such a question as this has not been settled long ago; and

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* An Address delivered at Coventry. The late Sir Bernard Samuelson, Bart., F.R.S., then one of the leaders in the educational movement, wrote to me as follows with regard to it:—"I have read your Coventry address with great pleasure. It has for the first time condensed into few words, easily understood by all, the whole problem of the Education of the Industrial Classes in this country. It avoids the exaggeration so common when technical instruction and its influence on industry is spoken of, and it does justice to the efforts of the Government."

further, that we can, if we wish, settle it now in the full light of the experience gained elsewhere, instead of wasting, let us say, a quarter of a century in costly experiments which may perhaps leave us in confusion worse confounded.

To begin, then, why is this question being discussed now?

There is a great fact embodied in the most concrete fashion in the way in which our Government is now compelled to deal with our national education. Side by side with the Education Department by which our Minister controls in the main that book learning which has been given time out of mind, there has sprung up during the last thirty years another department—the Science and Art Department—by which he controls a new kind of national learning altogether. We have added to the old study of books a new study of things.

This new learning was, we may say, only introduced in 1852, in which year the Queen in her speech on opening Parliament said, "The advancement of the fine arts and of practical science will be readily recognised by you as worthy the attention of a great and enlightened nation." We have since found out that they are indeed worthy the attention of a great nation, and more than this, that no nation can be called enlightened whose citizens are not skilled in both; in fact, that they are to peace what cannon and swords are to war. But for a nation to foster them is one thing, to include them in a national scheme of education is another.

Ought they to be so included? Let us see. What do we mean by education?

Roughly speaking, we may say that there are two

distinct schools of thought on this subject, although the existence of these two schools is not so generally recognised as it should be. According to one view, the human mind is an elastic bag into which facts are to be crammed for future use. A variation of the view is that the mind is inelastic, and then the stuffing process becomes more serious, and instead of depending upon a natural expansion, a process like that in use by the manufacturers of soda-water is employed. It is not to be wondered at that the youthful mind likes neither of these methods; what ought to be a true delight becomes a real agony, and hence it is, as a Warwickshire man wrote many years ago—

> "Love goes toward love
> As schoolboys from their books;
> But love from love
> Toward school with heavy looks."

—The mind on this view resembles a store where, as our American cousins say, everything, from a frying-pan to a frigate, which shall be useful to the owner in after-life is to be found. Hence such terms as Grammar School, Trade School, Science School, Commercial Academy, and hence, I am sorry to say, systems of examination which too often only serve to show what a boy can remember, and care little about either what a boy can do, or whether he can think.

So much for one view. Now for the other.

It is more difficult to image it, but, in the absence of a better illustration, the mind may be likened to the body—a thing to be trained so that its grace, its freedom, its strength, its grasp, indeed all its powers in all directions and in all ways may be brought out by proper training.

If the training is one-sided its power cannot be many-sided, but it is most useful when many-sided. Therefore, as each muscle of the body has to be properly trained to make a perfect man, so must the educational system brought into play be such as to train to its uttermost and bring out each quality of the mind. Each faculty of it when called into play becomes as a two-edged sword in the arms of a strong man. In this, or some such way, then, may we picture to ourselves the difference between instruction in its real sense and education in its real sense.

Now, which of these systems is the better one?

We shall see at once that the first may give us a mind stored with facts covering a large or a small area; it may be bookkeeping, or it may be Latin, or anything else. But will the mind be able to use this store in all cases? We grant *knowledge*, but may not *wisdom* linger? Those of us who have got to Voltaire's second stage, and who have studied men, know that this too often happens, and that much knowledge does not prevent the owner from being absolutely unfitted to grapple with the problems which each rising sun brings to him for solution. The other system, on the other hand, if the training is not thoroughly all-round, may give us a man who finds that the questions presented to him on his entrance to active life are precisely those which require the application of that quality of mind, whichever it may be, which was least trained at school. He may find himself face to face with problems of the existence of which he never dreamed, and so far removed from his experience that his mind, however powerful in some directions, fails to grapple with them.

We seem, then, on the horns of a dilemma. Instruction may provide us with a store of facts, which the mind does not know how to use. Education may provide us with a mind which has been trained in a world utterly different from the real one.

How can we escape from this dilemma? *We must use the materials of that instruction which is most useful to us in our progress through life as a basis for the complete education of the mind.* Which instruction is the most useful to us? The poet tells us that "the proper study of mankind is man;" but when we come to prose and read the views of those who best know the needs of modern society, and especially industrial society, we read something like this, which I quote from the report on elementary and middle class instruction, published by the Royal Commission of the Netherlands: "The idea of *Industrial Society* not limited to agriculture, manufactures, and trade or commerce, but understood in its widest signification, points plainly to the acquiring of the knowledge of the present world, and to its application to economical and technical pursuits."

Now, here is a subject on which a volume might be written, but I shall only point out to you the obviousness of the importance of the study, not merely of ourselves, *or* of the world around us, but of ourselves *and* of the world around us.

This lands us in the necessity of training our minds in literature or humanities, and science and art. The study of the humanities enables us to know the best thoughts, and the most stable conclusions on vital questions, arrived at by our forerunners and those who are fighting the same battles in other lands. The study of science enables

us, on the other hand, to get a true idea of the beautiful universe around us, of our real work in the world and of the best manner in which we can do that work in closest harmony with the laws of Nature. Did we study the external world alone we should not profit by the experience of those that preceded us. Did we study humanities alone we should be shorn of half our natural strength in face of many of the problems placed before us by the conditions of modern life; and, more than this, all the glories of the beautiful world on which our lot is cast, and the majesty of the universe of which that world forms part would hardly exist for us, or give rise only to dumb wonder.

Here let me tell you a little story. Three years ago when travelling in America, one morning, at a little station —we were approaching the Rocky Mountains—I was astonished to see a very old and venerable French curé in his usual garb enter the car, and as he was evidently in some distress of mind, and as evidently had little command of English, I asked him in his native language if I could be of any service to him. There was a difficulty about a box which I soon settled, and then we sat down and entered into conversation. He soon found out that I was very astonished to see him there and told me so. I acknowledged it. "It is very simple," he said. "I am very old, and six months ago I was like to die, and I was doing my best to prepare myself for the long journey. In my fancies I imagined myself already in the presence of *le bon Dieu,* and I fancied this question addressed to me, 'M. le curé, how did you like the beautiful world you have left?' I rose in my bed as this thought came into my head for I—I who—figure to yourself—had dared

to preach of a better world for fifty years, was, oh! so ignorant of this. And I registered a vow that if *le bon Dieu* allowed me to rise from that bed of sickness I would spend the rest of my life in admiring his works—*et me voici!* I am on my journey round the world; I am going now to stop at the Yosemite Valley a few days *en route* for San Francisco and Japan; and the box, Monsieur, which your kindness has rescued for me, contains a little scientific library, now my constant companion in my delicious wanderings."

Our general scheme of education, therefore, unless it is to be one-sided, must combine science with the humanities.

But, so far, I have said nothing about art. Now, from the educational point of view, science and art are very closely connected, inasmuch as in the early stages of both studies the student's powers of observation are brought out and trained in the most perfect way, while in the later stages, to succeed in either, he must have learned that very important thing—how to use his hands; and at whatever age you put it that a boy or a girl should use the hand neatly and skilfully, before that age you should take care that some elementary grounding, at all events, in the only training which can do this, shall have been given. No amount of Greek, or of useful or useless geography, or even of rule of three, can prevent the fingers being all thumbs, unless some such training has been given, and for the very earliest training drawing is undoubtedly the best. But this is by no means the only advantage of the combination. Any one who has to go over thousands of examination papers finds in nineteen cases out of twenty that an orderly drawing or diagram is

generally associated with an orderly mind. In fact, a diagram may be regarded as an index of the amount and accuracy of the knowledge possessed by the student. The text of the student who fails in the diagram is generally a more awkward jumble than the diagram itself. Hence the facts show that this training of the hand is accompanied by much good mental result. This is now so generally recognised, that in a not distant period no professor of biology, for instance, will attempt to demonstrate practically microscopic structure to students who have had no preliminary training in drawing. This is one example out of many which might be given, for as natural science is the study of nature, and as we can only study her by phenomena, the eye and the hand and the mind must work together to achieve success; and he who attempts to describe the geology of a district, the minute structure of a frog's foot, an eclipse of the sun, or the rings of Saturn, in words and words only, has only done half his work; to complete it he must appeal to art for aid.

Now, many of you may be prepared to concede, without any further insistence on my part, that an elementary acquaintance with art is of great, nay, of even essential importance, not only for its own sake, but because of its aid in natural studies. We must then add art to science and literature in order to form a complete curriculum. Here pardon me one moment's digression from the direct line of my argument. Many will agree that science is aided by art who deny that art is aided by science to the same extent. Indeed, some are prepared to urge that one who proposes to devote himself to art can derive no possible benefit from the study of science. Let us inquire into this a little. If we wish to excel in the art of figure-painting,

we must know anatomy, a most important branch of science; and as a matter of fact, many artists study anatomy as minutely as many surgeons do; and in the old days, when the artist and the poet were more saturated with the knowledge of the time than they are now, we find the great Leonardo at once professor of anatomy and founder of a school of painting as yet unsurpassed. If we pass from the figure to ornamental design, or if we wish to show objects in perspective, is not every line, whether straight or curved, dominated by an appeal to geometry?

Again, suppose we take landscape. Here we meet with phenomena of colour as much regulated by law as are the phenomena of form, and an anatomy of colour is fast being formulated, which to the artist of the future will be as precious as the anatomy of form has been in the past, and will ever continue to be. Let us take, for instance, an artist who wishes to paint a sunset, one of the most magnificent sights which it is given to man to witness. The sky is covered with clouds here and there, and not only do the colours of the clouds vary, almost from moment to moment, but in all cases they present the strongest contrast to the colour of the sky itself. The artist is bewildered, and finds each effect that he would seize to be so transient that at last he gives up in despair the attempt to note down the various tints. But the possession of a knowledge of the part played by the lower strata of our atmosphere in absorbing now one and now another of the components of the light of the setting sun, would change this despair into a joy almost beyond expression. For the bewildering changes of colour are then discovered to be bound together by a law as beautiful as the effects themselves.

There is another point of view. One is frequently pained in seeing in an otherwise noble work of art, evidences that the artist was crassly ignorant of the phenomena he attempted to represent, and in his attempts to transcend nature had only succeeded in caricaturing her, painting, for example, a rainbow in perspective, or a moon with its dark side turned towards the setting sun. Yet these are almost trifles, and, in fact, here we have the excuse of the ignorant artist—now, I am thankful to say, the representative of a class that is fast disappearing—for his defence is, that he has nothing to do with such small matters, and that accuracy of this kind may quite properly be sacrificed to secure the balance of his picture.

Now, to return to the main drift of my address, we have seen that in any complete system of education neither science nor art must be neglected by the side of the old humanities—the old literary studies; and it is indeed fortunate for us that we live in an age in which the laws and the phenomena of the external world have been studied and formulated with such diligence and success that it is as easy to teach science in the best possible way, as it is to teach classics in the best possible way.

It is half a century since the Germans found out the importance of the new studies from a national point of view. We are now finding it out for ourselves, and finding it out not a moment too soon; and I need hardly tell you that the transformation which is going on is acknowledged to be one of the highest national importance. It is no longer an abstract question of a method of education; it is a question of the life or death of many of our national industries, for, in a struggle for existence, how can a man who wins his bread by the

application of national laws to some branch of industry, if he be ignorant of those laws, compete with the man who is acquainted with them? If for man we read nation, you see our present position.

How far then have we got with our transformation, limiting our inquiry to primary and secondary instruction?

First, as to elementary education. The idea of the education—the compulsory education, if necessary, of all the citizens in a state—dates from the time of Luther. It is a horrible thing that we should have had to wait three and a half centuries since his time for such a measure, which is an act of simple justice to each child that is brought into the world. In 1524 Luther addressed a letter to the Councils of all the towns in Germany begging them to vote money, not merely for roads, dykes, guns and the like, but for schoolmasters, so that the poor children might be taught; on the ground that if it be the duty of a State to compel its able-bodied citizens to take up arms to defend the fatherland, it is *a fortiori* its duty to compel them to send their children to school, and to provide schools for those who, without such aid, would remain uninstructed.

Thanks to our present system, now about ten years old, out of an estimated population of 8,000,000 children between the ages of two and fifteen, we had last year nearly four millions at school, and out of an estimated population of 4,700,000 between five and thirteen, we had 3,300,000 at school.

Among this school population elementary science is at last to be made a class subject, and we find mechanics, mathematics, animal physiology and botany among the specific subjects in addition to the three R's. 120,000

children received education in these subjects last year, and if we are justified in assuming that as many will learn science when it becomes a class subject as now already learn drawing, we may expect in a year or two to have this 120,000 swelled into three-quarters of a million.

I must again insist upon the fact that practical teaching in science is the only thing that can be tolerated. Of course, with a new subject, the great difficulty is the difficulty of the teacher. Any system, therefore, of economising teaching power is of the highest importance. I am glad to know that a system suggested by Col. Donnelly, which uses the utmost economy of teaching power, has been carried into admirable practical effect at Birmingham, and I believe also at Liverpool, and other large towns. So that in the most important centres we may be certain that science will be taught in the best manner. It is worth while to dwell on this system for a moment. Under it practical teaching is given to boys and girls of the fifth and higher standards, and also to the pupil teachers. The subject chosen for the boys is mechanics, that for the girls domestic economy, giving each of these subjects a wide range of meaning. There is a central laboratory in which the experiments are prepared, and from which the apparatus ready for use is conveyed in a light hand-cart to the various schools—twenty-six in number in Birmingham—belonging to the Board. In this way it is possible to give twenty lessons a week, and the circuit of the schools can be made in a fortnight. In the intervals between the visits of the demonstrator the class teachers recapitulate his lessons and give the children written examinations. About 1,200 children are now being instructed in this way. To make the instruction as real as possible, children are

brought in to aid in performing the experiments, objects are passed round and questioning at the end of the lecture is encouraged. In the education, then, of our children from the ages of five to thirteen, we may reasonably expect to find that science teaching will in the future be carefully looked after.

We now come to secondary education. Here, again, great progress has been made during the last few years.

The real difficulties against its introduction have been the overcrowded state of the old curriculum, the scarcity of teachers, the want of sympathy with it, and the ignorance of its importance on the part of some headmasters. But to those headmasters who held the view that no real training could be got out of a subject which boys studied with positive pleasure, parents began to reply that whether the boy liked it or not he must get that knowledge somewhere. But where the experiment was really tried under good conditions it was soon found not only that the boys were willing to give three or four hours a week of their playtime to scientific subjects, but that the one or two hours filched from the curriculum were more than made up for by the greater ease with which the other subjects could be learnt, in consequence of the additional training of the mind which the new subjects gave.

We may hope, then, that in the course of time our secondary education may be much improved in the direction indicated. What we may expect, taking the principle of natural selection as our guide, will be this. First, the headmasters will themselves be men chosen, among other grounds, for their knowledge of science; they will become more and more all-round men. Next, the curriculum will be arranged not for the few who go to

the University, but for the many who do not. We shall have more science and less Greek in the early years of the school course. We shall have laboratories, and drawing rooms, and workshops. In some schools we may find modern living languages taught in a living way, replacing the dead languages altogether. Now, here our difficulties begin. We are face to face indeed with the same difficulties which the Continental nations, our precursors in educational matters, have experienced. Our secondary education is at the present moment all but absolutely separated from the primary one. Of the 4,000,000 scholars on the books of elementary schools last year there were only 44,000 over the age of fourteen, and it is to be feared that the remainder left school at that age, most of them, the best as well as the worst, to fight the battle of life with such an education as they had got up to that time. Germany, again, was the first to find out that this would never do, even though in that country science and art were taught in the Primary School; and for the reason that though such a meagre education might possibly do for ordinary workers in their hives of industry, it was totally insufficient for the future foremen, overseers and the like; and special schools were established to carry their education further. Quite of late years this question has been studied in the most interesting way in the Netherlands, under the advice of a wise minister, whose example will be followed some day in our own country.

Let me briefly refer to it.

This work began in 1863. In that year in Holland there were no middle class or secondary schools for artizans, but there were evening schools for drawing

which dated from 1872. "Burgher Schools" were established to provide the secondary instruction still felt to be needed by those who otherwise would have to content themselves with the primary instruction (although in its more extended form it contained natural philosophy, mathematics, and modern languages). In these schools—some day, some night schools (in these the lessons went on from September to May), with a course of two or three years—we find mathematics, theoretical and applied mechanics, mechanism, physics, chemistry, natural history, either technology or agriculture, drawing, gymnastics and other subjects among the fixed subjects, modelling and foreign languages being permissive. These burgher schools were compulsory in all parishes of 10,000 inhabitants. The evening burgher schools especially were at once seized on with avidity, chiefly by apprentices and the like.

Here let me give you some statistics which will show you how these schools were working even ten years ago. They are much more flourishing now, but I have not the figures. The statistics will show how the Dutch (of whom it cannot be said, to vary an old rhyme,

> In matters of *learning* the fault of the Dutch
> Is giving too little and asking too much,

for the instruction is practically free), who are already learning a trade or working at one, use the evening hours for the further cultivation of their minds.

	Population.	Number of students in burgher schools.
Delft	23,000	171
Utrecht	64,000	283
Deventer	81,000	285
Dordrecht	26,000	146

Among the students at these schools in 1874 were 1,582 carpenters and joiners, 472 smiths, &c., 236 plumbers and masons, 170 goldsmiths, engravers, &c., 320 painters, to give examples. Higher burgher schools were also established in the chief towns. In these schools still more advanced instruction was given: and here the course was for five years. In all these schools there was a considerable State endowment and an endowment on the part of the town, so that the fees were almost nominal, and in some cases even the instruction was gratuitous.

When I was inspecting these schools in Holland with an eminent man of science, whose advice had helped largely to make them such a success, and when I expressed to him my astonishment at the smallness of the fees—only a very few shillings a year—he put before me the question of State aid to schools in a way which had never struck me before. He said: "We regard it as a sort of education insurance. A small tax is paid by everybody during the whole of his life, and in this way a man who brings up children for the service of the State is helped by him who skirks that responsibility; and the payment which each citizen is called upon to make towards this instruction is spread over his whole life, and does not come upon him when he is probably most pinched in other ways."

Now for one practical result of the establishment of these schools. The year 1863 found Holland full of the notion that every hour a child spent away from the desk or the bench after thirteen was time wasted; but after these burgher schools were instituted a change came over the spirit of that dream, and now no employer of

labour in Holland, except of the lowest and most manual kind, will look at a boy who cannot produce a certificate from his burgher school.

Another very remarkable thing was soon observed, with a most important moral for us. The great difference between their burgher schools and the old gymnasia, the equivalents of our grammar schools, was a great infusion of science into the teaching, and the introduction of three modern languages in addition to Dutch; Latin and Greek being omitted altogether from the curriculum. After four years of this training, many of the boys showed such high promise that all connected with them thought it a pity that they should not enter a university. They were therefore, as an experiment, allowed six months to take up Latin and Greek, and the result was that in a great number of cases they beat the gymnasia boys in their own subjects, and passed into the university with flying colours. The Real Schule in Germany and the modern sides of our own secondary schools are almost the exact equivalents of the higher burgher schools to which I have especially called your attention.

What, then, is the experience which has been gained in these gigantic educational experiments ; experiments by which we may profit, as we are so late in the race, if we care to do so ? One point is that if a chance is put before those who have passed through the elementary schools of further culturing their minds, they seize upon it with avidity. Another is that the employers of labour appreciate the value of the greater intelligence thus brought about. It is better to have to instruct in a trade men who have shown themselves anxious to learn, than to have to do with blockheads. Another, I think, is this : Your best

secondary school is best for everybody; a secondary school with a properly mixed curriculum of literature, science and art, is best for him who proceeds either to the university or to the workshop. A second-rate education in a second-rate school gives us a second-rate man, and we do not want our national industries to be worked entirely by second-rate men. On this point I am glad to fortify what I have said by a reference to Dr. Siemens's important address at the Midland Institute some time ago. He says:—

"It is a significant fact that while the thirty universities of Germany [you see they do not educate by halves in Germany, they have seven times as many universities as we have in England] continued to increase, both as regards number of students and high state of efficiency, the purely technical colleges, almost without exception, have during the last ten years been steadily receding, whereas the provincial Gewerbe Schulen have, under the progressive minister, von Falke, been modified so as to approximate their curriculum to that of the gymnasium or grammar school. As regards middle-class education, it must be borne in mind that at the age of sixteen, the lad is expected to enter upon practical life, and it has been held that under these circumstances at any rate it is best to confine the teaching to as many subjects only as can be followed up to a point of efficiency and have reference to future application. It is thus that the distinction between the German gymnasium or grammar school and the Real Schule or technical school has arisen, a distinction which, though sanctioned to some extent in this country, also by the institution of the modern side, I should much like to see abolished."

We see then the gradually increasing weight of opinion, and the result of the experiments both in Germany and Holland, and I may add France, point to these conclusions.

Some kind of secondary education must be provided for the best students when they leave the elementary school, either before they begin work or while they are

at work. Our secondary education should advance practically along one line, how far soever the student goes along that line, some, of course, will go further than others, *provided always that it is the best possible, that is, one having the broadest base.*

Now, if this be generally conceded, our problem in England, at the present moment, is simpler than we thought it. We are face to face with the fact that it is for the good of the nation that those who have passed most successfully through the elementary education must continue that education in a secondary school ; whether for two, or for three, or for six years, matters little for the argument. Are we then to build technical schools for such students ? Thirty years ago the answer would have been yes. To-day we may say firmly, no. If a town has a grammar-school, let the town see that the curriculum of that school is based upon our best secondary models. If the town has no such school, then let it build one. If one school is not sufficient, then build two. That school will be the best off in the long run which gives the greatest number of free exhibitions from the elementary school into such a school as this, and that town will be the wisest which holds out such inducements at the earliest possible moment.

I have lately read with much interest a copy of resolutions and suggestions passed at a meeting of an Association of Elementary Teachers in the north of England. From these we may gather that this question is already one of practical politics. It is agreed that the secondary education of the best boys leaving the elementary schools must not end there. It is also taken for granted that the question lies between building a technical school or

utilising the grammar school. One argument used in favour of the latter course is, that the grammar school will be strengthened by drawing to itself the best boys from the elementary schools. The present proposals are that a number of free scholarships should be competed for annually, that these free scholarships shall, if need be, be supplemented by exhibitions from the fund at the disposal of the Governors (I should not accept this at once. Why should not the town pay them ?), and the length of time for which these scholarships shall be tenable is not to be less than three years.

You see, then, that in the north of England, at all events, it is conceded that the best children in our elementary schools should have a three years' course in a school of higher grade in which all the class subjects in the Elementary Code will be expanded, and all the linguistic studies of the grammar school taken in hand. When this system is at work, as it is bound to be in a few years, two things will happen, and it is as well we should be prepared for them. In the first place, our secondary schools—all of one model, the best model, let it be understood—must so arrange the curriculum, that the students can leave after a three years' course, if need be, for the workshop or the office, or after a longer course for the University. That is the first point. The second one is this. The present system of apprenticeship must be reconsidered. A boy who has been educated to the age of sixteen will learn very much more in three or four years, and will be very much more valuable to his master during that time than he who was formerly bound apprentice at the age of thirteen or fourteen, with his fingers all thumbs and no mind to speak of.

It seems to me, as it does to a daily increasing number, that the present mode of dealing with those matters which were formerly regarded as arts and mysteries known only to a few, and carried on on a small scale under the eye of the master, is dead against the system of apprenticeship as it has come down to us. Now the master does not teach and the boy in nine cases out of ten has no opportunity of grasping the whole of the art or mystery at all.

Many of you will begin to think that you are listening to the play of *Hamlet* with the part of the Prince of Denmark omitted, for so far I have said nothing whatever about technical education. I have said nothing about it for the reason that I believe the less said to a boy about technical education before he is sixteen years old the better. I now proceed to discuss this question, which is far more important, far more a national question, than you would gather from the debates in Parliament.

What is technical education ?

It is the application of the principles of science to the industrial arts. And the rock ahead against which I am anxious to join Dr. Siemens in warning you is this : Under the influence of the present scare—for it is a scare, and a real one—there is a chance that attempts may be made to teach the applications to those who are ignorant of principles, whereas we have to fight those who study applications with a full knowledge of the principles which underlie them.

We may congratulate ourselves on the fact that when we have once made up our minds as to the right place of technical instruction in our scheme of education, we have much of the necessary machinery already at our disposal ; and the recent action of the City Guilds and of the

Government is enormously increasing the quantity and improving the quality of this machinery.

Let us first consider the classes now formed all over the country under the auspices of the Science and Art Department. Their development in the last thirty years has been something truly marvellous.

When the Queen, in 1852, opened Parliament, there were already 35,000 students of art, but practically no students of science, in this country, amongst the industrial classes. That 35,000 will, if the present progress goes on, give us nearly 1,000,000 students of art at the end of this year; while the science schools have increased from 82 in 1860 to 1,400 in 1880, with 69,000 students. The system which has thus developed so enormously has dealt chiefly with pure science, but for the future we shall have side by side with it, and built upon the same lines, a system of teaching the applications of this pure science to each of our national industries. He who wishes in the future to have to do in any way with the manufacture of alkali, gas, iron, paper or glass, to take some instances, or in the dyeing of a piece of silk or the making of a watch, to take others, will find the teaching brought to his door and obtainable almost for the asking.

Here, again, we may congratulate ourselves, for while those who know most about the subject tell us that the more ambitious attempts at technical instruction in Germany and elsewhere have failed, because the teaching is not in sufficiently close contact with the works in which the processes are actually carried on, the system to which I have drawn your attention will enable the instruction to be given at night to those who have already begun practical work during the day.

We have, then, come to this: that putting together what is most desirable in the abstract, and what has been practically proved to be the best, the education of our industrial classes should be, and can easily be, something like this. The boy will go to an elementary school till he is thirteen. He will then pass with an exhibition, if necessary, to a secondary school till he is sixteen. He will there go on with his science—now a class subject in the elementary school—and begin the study of languages. At sixteen he will leave school and begin the battle of life, and can still in the evening proceed further with his studies in pure science, if the secondary education has left him too ill-equipped in that direction. Having thus got the principles of pure science into his mind he will be able to take up the technical instruction in the particular industrial art to which he is devoting himself.

But be the number of our future foremen and managers who have had this extra three years of secondary instruction, large or small, if there be in Coventry let us say out of your population of 45,000, 1,000 boys, or girls, or men, who are anxious not only to learn science, but its application to their particular industries, then the Government is ready to endow Coventry with a sum varying from 2,000*l.* to 6,000*l.* a year, according to the results of the examinations, if two subjects of pure science are taken up, and the students pass. The City Guilds are prepared to endow the town with from 1,000*l.* to 2,000*l.* a year additional, provided some application of the principles of science to the industrial arts is taken up, and evidence forthcoming that the principles themselves have been studied. Now if among your 45,000 there is not 1,000 who care for these things which are vital to your trades,

seeing that abroad these things are cared for, how can your trades stand against foreign competition? Let such a system as this go on for twenty years, and we shall hear nothing more of the decay of our national industries.

Now here I am bound to point out a distinct gap in the present system. We have classes for art, classes for pure science, classes for applied science, but where are the classes for languages?

The modern languages are taught so badly in our secondary schools, that it is hopeless to expect that sufficient knowledge, either of French or German, can be acquired in the three years' course to enable the student to find out what his French and German rivals are doing in the branch of industry which he takes up; and we must, moreover, consider those who may wake up to the importance of studying science and its technical applications after the chance of a secondary education is lost. Such classes then are a real want.

But I will not end my address by a reference to what I regard as an unfortunate gap, but would rather conclude what I have to say by pointing out that the scheme I have sketched out need be no Utopia, so far, at all events, as a supply of well-trained teachers is concerned. This, up to the present time, has been the real difficulty. But now that the authorities at South Kensington have started summer courses of lectures to teachers, and that they actually pay the teachers for going to learn, the method of teaching, both in the elementary and secondary schools, and evening classes, cannot fail to improve.

Quite recently, too, we have seen the inauguration of a Normal School, where Royal Exhibitioners and other free students are admitted without payment; where the

teacher has the first claim, and where he can attend any single course for a nominal fee.

Now every town of importance in the country should associate itself with the Government in this attempt, and should have one, at least, of its citizens always in training there, so that the scientific instruction in that town, whether primary, secondary or tertiary, should always be at its highest level. On the other side of the road, too, at South Kensington, is rapidly rising another institution where we may hope the teachers of our technical instruction will receive an equally careful training.

So that you see, to bring what I have to say to a conclusion, though we are late in the day, though many people have not yet made up their minds as to what is best to be done—and I acknowledge that the question is hedged in with difficulties on all sides—there is an easy solution of the difficulty based on the experience of other countries, which is at the same time an act of simple justice; that this solution requires, if we adopt it, no dislocation, but simply a natural growth of our existing means, and finally that all the newest developments of our educational machinery will fall naturally into place.

THE EDUCATION QUESTION IN 1883.

(1883.)

We are a long-suffering patient people. The call of Luther to those around him to educate their children and make men of them, as well as provide them with arms—a call at once answered in Germany—is only just now being answered among ourselves.

One of the most interesting and one of the most touching sights in London now, and one which in our view is a standing disgrace to the politicians who have held sway during the last hundred years, is the gradual rising above dingy roofs and millions of chimneys of the red brick board schools. The children in London at all events are now being educated, and our future masters are receiving the first rudiments of their instruction, and this much more on account of the intention of their fathers to have it for them than on account of any far-seeing policy of those who are popularly supposed to look in any and every direction for anything that may conduce to the well-being of our country.

We have at last got a public instruction, and it is already in the air that that instruction will in time be as free as it is now compulsory. It is a heartbreaking thing to look back and think what might have been had these all too recently built schools overtopped the squalid

dwellings of the poor a century ago. How much less squalid those dwellings would be now! The monumental and extensive prisons would probably be less occupied in their every cell than they are now, but the well-being of the country, the output of the country, would have been greater, and the struggle with penury, and dirt and crime would have been less.

This is only one aspect of education, but yet it seems that in this country, at all events, it is the mainspring of public opinion with regard to the general question. The cry—on many grounds the mistaken cry—for technical instruction has grown from the work of the board schools; it has gone along the same line at a higher level, and it will go on still further. The enormous development of the Government Science and Art Classes will also go on, and to the credit of the late Sir Henry Cole be it said here that he was wiser than the politicians, and his clear sight and single-mindedness influenced the head of the department with which he was connected, so that the work in science and art begun by the Prince Consort in 1851, long before the present notions of the importance of education really began to take root in our land, has been making quiet progress.

Now that compulsory education is in our midst, now that the importance of science and of art to the national industries is being gradually acknowledged, now that it is recognised that the education of our workmen must no longer be so disgracefully neglected as it has been, it is again suggested that there should be a Minister to look after these matters.

Ten years ago, as it was well put, the Kinderpest was the care of the Government side by side with the Rinderpest.

Both were practically on the same level, both were acknowledged to be nuisances, both might require a public department to look after them, and then money would have to be spent. This was quite a sufficient argument with "statesmen" to let things go on in the old harum-scarum way; for the policy of a Government is to keep money in its purse, honestly if it can, but in any case to do so, as if England were a miser, acknowledging no responsibilities, spurning all delights, and wishing to live a sordid life like the burghers of old, caring only for their dykes and pikes, who were shamed out of their indifference centuries ago.

There has again been a suggestion made that there should be a Minister of Public Instruction, who should be responsible for the preparedness of the country in this respect, just as the Minister of War is responsible for the preparedness of it in another direction. As long ago as 1856 the late Lord Derby said:—

> "It appeared to him well worthy of consideration whether it would not be well to have a Minister, or the head of a department, who should have no other duties to perform, and who should be, in fact, responsible for the education of the people . . . He had a strong feeling that the institution of a Minister of Instruction was desirable, that the subject should be altogether separated from the Privy Council."

But that did no good. In 1862 there was another resolution put to the House, calling on it to affirm that for the education estimates and for the expenditure of all moneys for the promotion of education, science and art a Minister of the Crown should be responsible to the House. That also did no good. In 1865 a Select Committee was moved for to inquire into the constitution of the Committee of the Council on Education. It was then urged that education

and science and art were beginning to be considered of such importance that—

> "The great duty of superintending the various branches connected with the Department of Education should be intrusted to some one responsible Minister, some Minister who should be regarded as a State officer of high authority, who should have the sole conduct of that department, and be solely responsible."

And that was shelved.

Nine years later, in 1874, the same view was urged, and Mr. Gladstone as Prime Minister admitted—

> "That there was much to be said in favour of the general principle that the expenditure of money for the promotion of education in science and in art should be placed under the control of a single responsible Minister."

It is true he said this, but he supported the previous question, so that again came to nothing.

Now that education and science are the great things of the day, not only in this but in all countries, England enjoys the proud pre-eminence of being the only country —civilised country, we know nothing of Timbuctoo—in which there is not a Minister of Public Instruction. It is lamentable, terrible, to read the debates, and to see the way in which the question was discussed. The importance of education, the importance of science, the importance of art—the daily, almost hourly, increasing importance of these things—do not seem to have entered into the question. To a large extent it was merely a question of Cabinet convenience and Parliamentary tweedledum and tweedledee. How can there be made room in the Cabinet for a Minister of Public Instruction? Are not the affairs of the Duchy of Lancaster of much greater importance, and would not the recognition of the importance of education make the Cabinet unwieldy and give rise to difficulties in

Parliamentary procedure? And then there is the Scotch business that must be looked after first, and so on, and so on. Education is evidently not in the regions of practical politics.

Heaven knows changes sufficiently great have been made of late years, and it is not absolutely certain that the fundamental bearings of the nature of the changes to be made have in all cases been fully considered; but it seems as if they are to be most carefully considered before any change is made touching the matter of education.

Still it is acknowledged that the question is, after all, one that deserves the attention of Parliament. Mr. Gladstone, however, had, as usual, three objections to make. In the first place he expressed very great doubt whether, if he had a plan ready to alter the present arrangement, it would be wise to make any declaration on the subject by way of motion. Secondly, he admitted that there was no plan, and he did not think the time had arrived for one; and lastly, he considered that the subject ought to be a great deal more examined before the House committed itself to a final opinion whether there should be a plan or not.

With reference to his first objection he stated that the House knew perfectly well that administrative changes are made piecemeal, and must continue to be so; and he remarked that there was a good deal to be said in favour of what was called a patched house, because most of us found it the most comfortable sort of house to live in. A Minister of Public Instruction would be a new patch, and as there is patching going on elsewhere he objects to this; and so on, and so on.

The argument which he used in favour of the second

objection was, we imagine, the strongest he could have used against it, namely, that the business of the Council Office in respect to education has been in an almost incessant state of flux and change; there can be no doubt that the flux and change will get more pronounced as time goes on. That is the very reason why everything should be brought to a focus.

We may gather from Mr. Gladstone's speech that the Universities should ever, in his opinion, remain divorced from the general question of education; but if so, what is to become of Professor Huxley's ladder from the gutter to the university?

It is worth while to cull the following from the speech of Mr. Foster, an old Vice-President of the Committee of the Council on Education:

"The Committee of the Council for Trade, or Agriculture, or Education meant nothing whatever. Persons might imagine that the Privy Council occasionally met for the transaction of business, but they never did so either in England or Ireland. The Minister for Agriculture was the President of the Committee of the Council on Agriculture, but he greatly doubted whether that Committee ever met, or ever would meet. . . The real objection (to Sir John Lubbock's proposal) probably was that it was undesirable to make too much of education, that if we were to have a Minister of Education he might be pushing things on too quickly. . . There might be a fear that under one Minister too much money would be spent. . . What was complained of now was that there was no really defined responsibility. The man who moved the Estimates and did the work was not the head of a Department, and he ought to be. The work was done by a Minister who was controlled by another, and the latter was scarcely seen by the public. He did not see why we should continue that Japanese mode of managing affairs."

It is satisfactory to see that the House of Commons is gradually getting into a better position to discuss such questions as these, but we have felt that the main point is

that the head of the Government does not yet consider that the question of education is one of importance sufficient to be discussed side by side with what in his opinion is the much larger question of Parliamentary procedure It is true a Select Committee has been agreed to, but it is to be feared that after Mr. Gladstone's speech very little will come of it, as has happened before.

The result remains that we are not to have a Minister of Education. There is agricultural business, including the rinderpest and other matters, and these are larger questions than that of national education! Therefore national education must wait. As was said before, we are a long-suffering and patient people. There is, however, little doubt that in some political programme of the future this question will find a place; equal electoral districts and the payment of members are not the only things to be cared for.

LORD PLAYFAIR AND OTHERS ON OUR EDUCATIONAL NEEDS.

(1885.)

If it be fair to forecast the success of a meeting of the British Association by the quality of the addresses delivered by the various presidents, then it may be predicted that the meeting in 1885 at Aberdeen, with Lyon Playfair as President, will long stand out among its fellows.

The growing use, as well as the growing feeling for the need, of scientific methods comes out in a most unmistakable way, while there is no fear that either hearers or readers will be lulled into a sleepy hollow of satisfaction or a rest-and-be-thankful feeling. For that much remains to be done even in the way of initial organisation both of teaching and working is frankly and fearlessly acknowledged by several of the speakers.

These present needs, pointed out by the President of the Association himself, who speaks both as a man of science and a politician, may well occupy our attention. No one knows better than Sir Lyon Playfair how science can aid the body politic, or knows better how each party when in office neglects or uses this powerful engine for the nation's good. He begins by quoting these noble words from the address of the President at the Aberdeen meeting in 1859—the lamented Prince Consort ;

"We may be justified in hoping . . . that the Legislature and the State will more and more recognise the claims of science to their attention, so that it may no longer require the begging box, but speak to the State like a favoured child to its parent, sure of his paternal solicitude for its welfare; that the State will recognise in science one of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand."

One can get no better idea of the Philistine condition of the Government and of the House of Commons in matters of science than from the fact that much of what follows in the President's Address has not been said in the House itself instead of at Aberdeen. The real reason, perhaps, is to be gathered from a remark made by Professor Chrystal in his address in Section A:

"We all have a great respect for the integrity of our British legislators, whatever doubts may haunt us occasionally as to their capacity in practical affairs. The ignorance of many of them regarding some of the most elementary facts that bear on every-day life is very surprising. Scientifically speaking, uneducated themselves, they seem to think that they will catch the echo of a fact or the solution of an arithmetical problem by putting their ears to the sounding-shell of uneducated public opinion. When I observe the process which many such people employ for arriving at what they consider truth, I often think of a story I once heard of an eccentric German student of chemistry. This gentleman was idle, but, like all his nation, systematic, When he had a precipitate to weigh, instead of resorting to his balance. he would go the round of the laboratory, hold up the test-tube before each of his fellow-students in turn, and ask him to guess the weight. He set down all the replies, took the average, and entered the result in his analysis."

Now if this view of our legislators is shared by men of such acumen as Sir Lyon Playfair and others in the House of Commons more or less connected with science, we can well understand their silence in the modern council of the nation which so little resembles the Witanagemote of former times.

In his pleading for more State recognition of science the President points out the present activity of Germany and France, and especially of the United States:

"... Both France and Germany make energetic efforts to advance science with the aid of their national resources. More remarkable is it to see a young nation like the United States reserving 150,000,000 acres of national lands for the promotion of scientific education. In some respects this young country is in advance of all European nations in joining science to its administrative offices. Its scientific publications, like the great palæontological work embodying the researches of Professor Marsh and his associates in the Geological Survey, are an example to other Governments. The Minister of Agriculture is surrounded with a staff of botanists and chemists. The Home Secretary is aided by a special scientific Commission to investigate the habits, migrations and food of fishes, and the latter has at its disposal two specially constructed steamers of large tonnage. The United States and Great Britain promote fisheries on distinct systems. In this country we are perpetually issuing expensive Commissions to visit the coasts in order to ascertain the experiences of fishermen. I have acted as Chairman of one of these Royal Commissions, and found that the fishermen, having only a knowledge of a small area, gave the most contradictory and unsatisfactory evidence. In America the questions are put to Nature, and not to fishermen. Exact and searching investigations are made into the life-history of the fishes, into the temperature of the sea in which they live and spawn, into the nature of their food and into the habits of their natural enemies. For this purpose the Government give the co-operation of the Navy and provide the Commission with a special corps of skilled naturalists, some of whom go out with the steamships, and others work in the biological laboratories at Wood's Hall, Massachusetts, or at Washington. . . The practical results flowing from those scientific investigations have been important. The inland waters and rivers have been stocked with fish of the best and most suitable kinds. Even the great ocean which washes the coasts of the United States is beginning to be affected by the knowledge thus acquired, and a sensible result is already produced upon the most important of its fisheries. The United Kingdom largely depends upon its fisheries, but as yet our own Government have scarcely realised the value of such scientific investigations as those pursued with success by the United States."

He quotes with approval a passage from Washington's farewell to his countrymen: "Promote as an object of primary importance institutions for the general diffusion of knowledge. In proportion as the structure of a Government gives force to public opinion it is essential that public opinion should be enlightened." He next points out that it was not till 1870 that England established a system of education at all, and that now, while all great countries except our own have Ministers of Education, we have only Ministers who are managers of primary schools.

Passing on to the State need of abstract knowledge we read as follows:

> "Ali, the son-in-law of Mahomet, the fourth successor to the Caliphate, urged upon his followers that men of science and their disciples give security to human progress. Ali loved to say, 'Eminence in science is the highest of honours'; and 'He dies not who gives life to learning.' In addressing you upon texts such as these my purpose was to show how unwise it is for England to lag in the onward march of science when most other European Powers are using the resources of their States to promote higher education and to advance the boundaries of knowledge. English Governments alone fail to grasp the fact that the competition of the world has become a competition in intellect."

We have seen how Sir Lyon Playfair twits the heads of the Education Department with being merely managers of primary schools. The President of the Chemical Section, Professor Armstrong, also shows reason why their functions must be expanded if science is ever to get on here. He holds that without State action the difficulties which at present prevent the existing teaching institutions from exercising their full share of influence upon the advancement of our national prosperity are all but insuperable. He foresees the objection that such an interference would deprive teaching centres of their

individuality, but he denies that this must necessarily follow, and we know no one who has a better right to express an opinion on such a subject.

Some part, indeed, of Professor Armstrong's address is terrible reading. The present chemical education and chemical examinations in this country are, according to him, to a large extent shams and worse. The students who come to the centres of higher instruction are scarcely reasoning beings—they have never been brought to reason; and at those centres the instruction has been of too technical a character, while hardly anywhere is there an atmosphere of research. He points out, among many other matters, the vital importance of the research atmosphere, and he frankly states the difficulties felt by earnest men. Many of the remarks so often made now touching the absence of research in our chemical laboratories apply not to such men as him, but to those whose trading spirit and proclivities are well known—men who discredit the profession to which they belong. Still, it is well that the difficulties should be fairly recorded, especially in juxtaposition with a statement that absence of research must always indicate the absence of teaching worthy of the name.

A complete revision of the present system, both of teaching and examining in chemistry, is, therefore, according to Professor Armstrong, one of the most pressing of our present needs.

Are the other sciences better off? Certainly not mathematics if Professor Chrystal has a right to speak for that branch:

"All men practically engaged in teaching who have learned enough, in spite of the defects of their own early training, to enable them to

take a broad view of the matter, are agreed as to the canker which turns everything that is good in our educational practice to evil. It is the absurd prominence of written competitive examinations that works all this mischief."

But some may think that in the setting of problems mathematics teachers have an advantage over others in preventing unintelligent cramming. This is not Professor Chrystal's opinion:

"The history of this matter of problems, as they are called, illustrates in a singularly instructive way the weak point of our English system of education. They originated, I fancy, in the Cambridge Mathematical Tripos Examination, as a reaction against the abuses of cramming bookwork, and they have spread into almost every branch of science teaching—witness test-tubing in chemistry. At first they may have been a good thing; at all events the tradition at Cambridge was strong in my day, that he that could work the most problems in three or two and a half hours was the ablest man, and, be he ever so ignorant of his subject in its width and breadth, could afford to despise those less gifted with this particular kind of superficial sharpness. But, in the end, it all came to the same; we were prepared for problem working in exactly the same way as for bookwork. We were directed to work through old problem papers, and study the style and peculiarities of the day and of the examiner. The day and the examiner had, in truth, much to do with it, and fashion reigned in problems as in everything else. The only difference I could ever see between problems and bookwork was the greater predominance of the inspiriting element of luck in the former. This advantage was more than compensated for by the peculiarly disjointed and, from a truly scientific point of view, worthless nature of the training which was employed to cultivate this species of mental athletics. The result, so far as problems worked in examinations go, is, after all, very miserable, as the reiterated complaints of examiners show; the effect on the examinee is a well-known enervation of mind, an almost incurable superficiality, which might be called Problematic Paralysis—a disease which unfits a man to follow an argument extending beyond the length of a printed octavo page."

As to the crying present need, Professors Chrystal and Armstrong are at one. We want a higher ideal

of education in general, and of scientific education in particular :

"Science cannot live among the people and scientific education cannot be more than a wordy rehearsal of dead text-books, unless we have living contact with the working minds of living men. It takes the hand of God to make a great mind, but contact with a great mind will make a little mind greater. The most valuable instruction in any art or science is to sit at the feet of a master, and the next best to have contact with another who has himself been so instructed. No agency that I have ever seen at work can compare for efficiency with an intelligent teacher who has thoroughly made his subject his own. It is by providing such, and not by sowing the dragon's teeth of examinations, that we can hope to raise up an intelligent generation of scientifically educated men who shall help our race to keep its place in the struggle of nations. In the future we must look more to man and to ideas, and trust less to mere systems. Systems have had their trial. In particular, systems of examinations have been tested and found wanting in nearly every civilised country on the face of the earth."

What we have written will show what food for thought in the matter of our present needs has been provided at Aberdeen for those gathered together for the advancement of science. Surely the three addresses specially referred to suggest a gap in the organisation of the Association. Why should there not be a section to deal specially with the question of education and research ?

Today
20th Dec. 1950

SCIENCE AND EDUCATION DURING VICTORIA'S REIGN.

(1887.)

Most of the celebrations connected with the fiftieth anniversary of the Queen's accession will soon have taken place; and in London, at all events, the gorgeous ceremonials now being prepared will have been the admiration of hundreds and thousands of Her Majesty's loyal subjects. It is therefore quite right and fitting that we should dwell for one moment on the subject now uppermost in all minds, and dear to most British hearts. In loyalty the students of Nature in these islands are second to none, and their gladness at the happy completion of the fifty years' reign, and their respect for the fifty years' pure and beautiful life, are also, we believe, second to none. But the satisfaction which they feel on these grounds is tempered when they consider, as men of science must, all the conditions of the problem.

The fancy of poets and the necessity of historians have from time to time marked certain ages of the world's history and distinguished them from their fellows. The golden age of the past is now represented by the scientific age of the present. Long after the names of all men who have lived on this planet during the Queen's reign, with the exception of such a name as that of Darwin, are forgotten,

when the name of Queen Victoria even has paled, it will be recognised that in the latter half of the nineteenth century a new era of the world's history commenced. Whatever progress there has been in the history of any nation during the last fifty years—and this is truer of England than of any other country—the progress has been mainly due to labourers in the field of pure science, and to the applications of the results obtained by them to the purposes of our daily and national life.

It is quite true that some men of Science take a pride in the fact that all this scientific work has been accomplished not only with the minimum of aid from the State, but without any sign of sympathy with it on the part of the powers that be.

We venture to doubt whether this pride is well founded. It is a matter of fact, whatever the origin of the fact may be, that during the Queen's reign, since the death of the lamented Prince Consort, there has been an impassable gulf between the highest culture of the nation and royalty itself. The brain of the nation has been divorced from the head.

Literature and science, and we might almost add art, have no access to the throne. Our leaders in science, our leaders in letters, are personally unknown to Her Most Gracious Majesty. We do not venture to think for one moment that either Her Majesty or the leaders in question suffer from this condition of things; but we believe it to be detrimental to the State, inasmuch as it must end by giving a perfectly false perspective; and to the thoughtless the idea may rise that a great nation has nothing whatever to do either with literature, science or art—that, in short, culture in its widest sense is a useless excrescence, and

properly unrecognised by royalty on that account, while the true men of the nation are only those who wield the sword, or struggle for bishoprics or for place in some political party for pay and power.

The worst of such a state of things is that a view which is adopted in high quarters readily meets with general acceptance, and that even some of those who have done good service to the cause of learning are tempted to decry the studies by which their spurs have been won.

If literature is a "good thing to be left," as Sir George Trevelyan has told us, if Mr. Morley, the politician, looks back with a half-contemptuous regret to the days when he occupied a "more humble sphere" as a leader of literature, if students are recommended to cultivate research only "in the seed-sowing time of life;" are not these things a proof that something is "rotten in the State," even in this Jubilee year? It surely is well that literature, science and art should be cultivated by men who are willing to lay aside vulgar ambition of wealth and rank, if only they may add to the stock of knowledge and beauty which the world possesses. It surely is not well that no intellectual preeminence should condone for the lack of wealth or political place, and that as far as neglect can do it each scientific and literary man should be urged to leave work, the collective performance of which is nevertheless essential to the vitality of the nation.

It would seem that this view has some claims for consideration when we note what happens in other civilised countries. If we take Germany, or France, or Italy, or Austria, we find there that the men of science and literature are recognised as subjects who can do the State some service, and as such are freely welcomed into the councils of

the Sovereign. With us it is a matter of course that every Lord Mayor shall, and every President of the Royal Society shall not, be a member of the Privy Council ; and a British Barnum may pass over a threshold which is denied to a Darwin, a Stokes or a Huxley. Our own impression is that this treatment of men of culture does not depend upon the personal feelings of the noble woman who is now our Queen. We believe that it simply results from the ignorance of those by whom Her Majesty is, by an unfortunate necessity, for the most part surrounded. The courtier class in England is—and it is more its misfortune than its fault—interested in few of those things upon which the greatness of a nation really depends. Literary culture some of them may have obtained at the universities, but of science or of art, to say nothing of applied science and applied art, they for the most part know nothing ; and to bring the real leaders of England between themselves and the Queen's Majesty would be to commit a *bêtise* for which they would never be forgiven in their favourite *coteries*. No subject—still less a courtier—should be compelled to demonstrate his own insignificance. That this is the real cause of the present condition of things which is giving rise to so many comments that we can no longer neglect them, is, we think, further evidenced by the arrangements that have been made for the Jubilee ceremonial in Westminster Abbey. The Lord Chamberlain and his staff, who are responsible for these arrangements, have, it is stated, invited only one Fellow of the Royal Society, as such, to be present in the Abbey ; while with regard to literature we believe not even this single exception has been made. It may be an excellent thing for men of science like Professor Huxley, Professor Adams and Dr. Joule, and such a man of

literature as Mr. Robert Browning, that they should not be required to attend at such a ceremonial, but it is bad for the ceremonial. The same system has been applied to the Government officials themselves. Thus, the department responsible for science and art has, we believe, received four tickets, while thirty-five have, according to Mr. Plunket's statement in the House, been distributed among the lower clerks in the House of Commons. Her Gracious Majesty suffers when a ceremonial is rendered not only ridiculous but contemptible by such maladministration. England is not represented, but only England's paid officials and nobodies.

While we regret that there should be these notes of discord in the present condition of affairs, there can be no question that Her Majesty may be perfectly assured that the most cultured of her subjects are among the most loyal to her personally, and that they join with their fellow-subjects in many lands in hoping that Her Majesty may be long spared to reign over the magnificent Empire on which the sun never sets, and the members of which science in the future will link closer together than she has been able to do in the past.

EDUCATION AND INDUSTRY.

(1895.)

At last the daily press is beginning to see the necessity of State action to prevent as far as possible the ruining of many of our industries threatened by the development of scientific research and processes in other countries.

*The Times** has spoken out with no uncertain sound in connection with the often repeated cases in which, in various foreign markets, English are being replaced by German goods. The paragraph to which we refer runs as follows :—

"Our Berlin correspondent called attention two days ago to the immense strides made by German industry during the last quarter of a century, and to the failure of our Government to pay any adequate attention to a development so closely concerning British interests. In this commercial age this industrial nation has one commercial Attaché in Paris who is supposed to keep an eye upon all Europe, and one at St. Petersburg, who has all Asia for his province. A commercial Attaché at Berlin for Germany alone would find ample occupation and would furnish knowledge of things that deeply concern us, which it may be feared neither the Government nor the mercantile classes of this country possess at present. We also require urgently a commercial Attaché with especial qualifications for the Far East. Yesterday our Paris correspondent informed us that on his first appearance as Minister for Foreign Affairs M. Berthelot asked money for the establishment of six new consulates in China. The contrast is sufficiently striking

* November 27, 1895.

between the policy of the two countries and the difference runs through the entire treatment of the material interests of the two peoples. Both in Germany and in France it is held an essential part of the duty of the State to second, and not only to second, but to stimulate and direct the efforts of private enterprise. In this country, though State interference with commerce is being carried to a dangerous length, State assistance, even in the way of collecting information, is regarded with stupid distrust and disfavour. Our home industries themselves in many cases languish for want of intelligent direction. Our agricultural distress might be alleviated were the State not far above the education of the population in the minor agricultural arts, and the organisation of agricultural industries after the manner in vogue on the Continent. In the same way, although nothing can excuse the short-sighted folly of our manufacturing classes in not providing for scientific research in the various branches of industry, yet it is the duty of a wise Government to take measures to counteract the folly of classes when it threatens the general interest. In one word, Great Britain stands at this moment in imminent danger of being beaten out of the most lucrative fields of commerce, simply because it does not recognise, while other nations do, the value of scientific organisation in the field, in the workshop, in the laboratory and in the conduct of national policy."

The public meeting to promote a memorial to Huxley reminds us how much we have lost—how much weaker we are for his absence. Never was Huxley more emphatic than when he pleaded, years ago, for the organisation of our scientific forces, so as to secure the victories of peace. It is now certain that we have lost many of these peaceful battles, and that we shall lose more, because our legislators have either not read the signs of the times, or have been led by those who, if they were consistent, would bring back our Navy to its state in Queen Elizabeth's time, when it was the outcome of individual and local effort.

It is encouraging to think that when the attention of the commercial classes has been drawn to what is happening, as it must be before long, and when the public will possess full knowledge of the utter chaos of our public

departments in all things appealing to the national life so far as it depends upon commercial enterprise under the existing conditions, some action must be taken. We have Committees of the Privy Council for this and that and the other departments, but where are the Scientific Privy Councillors? Where are the meetings held at which they give the State the benefit of their knowledge? In what record do we find the minutes of such "My Lords" as these?

It is not fair even to the administrators of the several departments that the present state of things should be allowed to exist. Too few of these have been chosen on account of their scientific knowledge, and as each question arises they have to pick up their information as best they can. There are several ways of doing this, one of them indicated by the Board of Trade inquiry into the revised regulations referring to the Electric Lighting Acts. The Conference showed conclusively how much the Department gained by the free imparting of knowledge by outsiders,

But this is only one direction in which reforms are needed. The Chambers of Commerce throughout the country must sooner or later take the matter up; and when this is done, many other ways of abolishing the existing chaos will suggest themselves.

SCIENTIFIC EDUCATION IN GERMANY AND ENGLAND.

(1896.)

Professor Ramsay has done good service by communicating to *The Times* a letter he has received from Professor Ostwald of the highest importance at the present time, when, fortunately for us, German supremacy along many lines of applied science and the causes of it are being at last recognised.

No one has a better right to speak on this subject than Professor Ostwald, and the fact that we may take his communication as one made in the interests of British science makes it all the more valuable.

What he says will be no news to those who for years past have been pointing out the rocks ahead and the steps necessary to avoid them ; but their voice has been as that of one crying in the wilderness. Fortunately for us this is so no longer. *The Times* devotes a leader to Dr. Ostwald's letter, but it does not appear that even *The Times* is in real touch with the actual position.

> "The Germans have found that nothing pays so well as knowledge, and that new knowledge always pays in the long run. They act on this principle by maintaining a steady demand for men competent to extend the domain of theoretical knowledge, paying them well for doing it, and taking their chance of one valuable practical discovery turning up among a score that for the present lead to nothing. How good that

chance is may be judged from the enormous success attending German chemical industries of all kinds. Germany controls the fine chemical markets of the world, and that means that she takes tax and toll of almost every industry in every country. How easily we might have forestalled her can be fully understood only by those who know what a splendid start we had in capital, in machinery, in control of markets, and in root ideas. Some of her most lucrative industries have been developed out of English discoveries, due to the genius of individual Englishmen, but never properly grasped and worked out by English manufacturers. Her commercial domain will go on extending, and ours proportionately shrinking, unless Englishmen become practical enough to look beyond their noses, and wise enough to believe in knowledge."

This is excellent; but then we are also told—

"For any healthy reform we want driving power, and the driving power must come from manufacturers enlightened enough to understand the secret of German success and English failure. It is industry that must endow research, not from any unpractical desire to add to the number of useless persons who know all that has been done, yet do not know how to do anything new, but from the very practical desire of manufacturers to extend their business and add to their profits."

And again:—

"There is a clamour now and again for State aid, and Dr. Ostwald's letter will, perhaps, stimulate it, because he refers to the action of the State in Germany. But the root of the matter in Germany lies in private enterprise, and it must do so here. Heaven helps those who help themselves, and the State cannot do better than observe the same limitation. When industry endows research it will be time to ask for assistance from the taxpayer. Until then State endowment of research can mean little more than throwing money away upon abstract acquirements having no real relation to the facts of national prosperity."

Let us accept for a moment that "industry," "manufacturers," and "private enterprise" in Britain at once proceed to do all that *The Times* lays at their doors. What then? Professor Ostwald answers this question by telling us what the Prussian Government and the various German States have done and are doing for research and scientific education, above and beyond all the efforts

made by German "industry," "manufacturers" and "private enterprise."

In such a competition Britain, without the State aid so amply and wisely given in Germany, is certain to lose.

It has already been pointed out, and it is worth while to re-state it, that the connection between out national greatness, our national defences and our commerce, is universally recognised, and that the State spends, and properly spends, tens of millions a year, the protection of our commerce being assigned as one of the ostensible reasons.

But another thing which as yet is not generally recognised is that so surely as our national greatness is based upon our industries, as surely in the future must our industries be based upon science.

It is clear, therefore, that if in other countries the advancement of science is the duty not only of individuals, but of States, mere individual effort in any one country must be crushed out in the international competition which is growing keener and keener every day.

Taking things as we find them, we spend tens of millions a year to protect our commerce which is a measure of our industries; while the basis of these, science, is to remain unprotected, unorganised and unaided, except by local efforts and the action of individuals.

Surely such a contention cannot be seriously maintained—such inconsistent action can have no logical basis. The real remedy lies in consistently organising both our peace and our war forces, as Huxley pointed out many years ago. We have now a War or Industries-protecting Council: by the side of it we want a Peace or Industries-producing Council; in other words, a strong

Minister of Science, who shall have as complete a staff of men of science to advise him as the President of the War Council finds himself provided with in the heads of the Army and Navy Departments.

Only in this way can Germany's flank be turned. If it were only a question of ironclads how readily everybody would agree.

Another part of Professor Ostwald's letter, for which thanks are due, is that in which he points out that in Germany research is as important an engine in Education as it is in a Chemical Works; so that again the call upon "private enterprise" is not sufficient.

Here, of course, the whole question of our University organisation is raised. We cannot pursue it now, but we may quote a pregnant passage from Professor Fitzgerald—

> "The most serious cause of complaint of modern society against the old universities is that they have so controlled the education of the wealthy classes of the community, that the landed and professional classes have been educated apart from the commercial and industrial classes, to the very great injury of both."

This is the reason that the true condition of things has not been appreciated long ago. It is not understood, and therefore it is not believed. Our political leaders, the permanent chiefs of the various public departments, have not the slightest idea what all this fuss is about, because their education has been entirely apart from those regions of thought and work in which in the future the peaceful battles of the world will be fought and won; if not by us, then by others, for fighting there must be.

No better argument could be found for the establishment of a ministry and council of science than was afforded by two speeches delivered some little time ago by the Duke of Devonshire on matters connected with scientific

education. The Duke candidly confessed at Birmingham that he was not placed at the head of the educational and scientific affairs of the country on account of any special knowledge of the subjects, for "his knowledge of science and art could be compressed into two nutshells." It is not our desire to utter one word against the Duke of Devonshire for his candour; he has shown that he is interested in technical education, and has on more than one occasion assisted the work of science. But what we do criticise is the political system which does not consider it necessary that the educational and scientific welfare of the country should be the business of those who are able to appreciate the work done, to see the necessity of reforms, and to know the directions in which developments should take place. In almost every other country the State or Government has official men of science among its servants, and also constantly asks the advice and assistance of their academies and learned societies, when questions of technical and scientific public interest are under discussion; but here no such use is made, either of the societies as a whole, or of the men who constitute them.

[Professor Ostwald's letter ran as follows; it is so important that I reprint it here :—

"In our frequent discussions on scientific education, we have both often been struck with some points of very great difference between the English and the German way of dealing with it. As it may be asserted without national arrogance that University education is in Germany in a more satisfactory condition than in your country, you are, of course, anxious to know which of the German customs I consider most effective in bringing about this better state of things; and I will, therefore, try to point them out. Of course, I shall confine myself to the subject of natural science, and especially chemistry

and physics, feeling myself unable to deal with sciences beyond my knowledge. The main point of our system may be expressed in on word—freedom—freedom of teaching and freedom of learning. The first involves for the teacher the necessity of forming in his mind a clear conception of the scope of his science, for, as he is free to choose any possible method of view, he feels himself answerable for the particular one he has chosen. And in the same way the student feels himself responsible for the method and the subject of his studies, inasmuch as he is free to choose any teacher and any subject. One who has not seen this system in action may be inclined to think that such a system must lead to arbitrary and irresponsible methods on the side of the teacher, and to confusion on the part of the student. But the former is avoided, because at the beginning of his career the teacher is dependent for his advancement on the results of his scientific views, and is naturally anxious to improve his position in the educational world. And as for the students, they themselves impose certain restrictions on their own freedom. Most of them feel that they require some advice and guidance, and they therefore follow the usual and approved order in conducting their studies. As to the inventive man of original ideas, it has often been proved that for him any way is almost as good as any other, for he is sure to do his best anywhere. Moreover, such a man very soon excites the interest of one of his teachers, and is personally led by him, generally to the great advantage of both.

"Let me illustrate these general remarks by considering the course followed by an average chemist. In his first half-year he hears lectures on inorganic chemistry, physics, mineralogy, sometimes botany, and of late often differential calculus. Moreover, the German student is accustomed to take a more or less strong interest in general philosophy or history, and to add in his *Belegbuch* (list of lectures) to the above-named *Fachcollegien* (specialised studies) one or two lectures on philosophy, general or German history, or the like. Very often there are in the University one or more popular professors whose lectures are heard by students of all faculties without reference to their special studies. The student who has heard during his stay at the University only lectures belonging strictly to his *Fach* is not well thought of and is to some extent looked down on as a narrow specialist. But I must add that such views are not prevalent in all faculties, and there are some—*e.g.*, the faculty of law—whose students confine themselves, with few exceptions, to attending exclusively lectures in that faculty.

"In the second half-year the chemical student begins with practical laboratory work. Notwithstanding the perfect freedom of the teachers,

the system first introduced by Liebig into his laboratory at Giessen is still universally adopted in German universities and technical high schools—viz., qualitative and quantitative chemical analysis, the former conjoined with simple spectroscopic work, the latter amplified by volumetric analysis. This is followed by a course of chemical preparations, formerly chiefly inorganic, now chiefly organic. Even here, a regular system is being widely developed owing to the use of some well-known text-books. Of late years this course is followed in some laboratories by a series of exercises in physical chemistry and electro-chemistry.

"While these practical exercises, which last for three or four half-years, are being carried out, the student completes his knowledge of physics, mathematics, and the other allied sciences by hearing lectures and working practically in the physical and often also in some other laboratory. The exercises done, he goes to the professor and asks him for a 'theme' to begin his 'work'—viz., his dissertation for the degree of Doctor of Philosophy. This is the most important moment in his life as a student, for it generally determines the special line of his future career. The 'theme' is usually taken from the particular branch of the subject at which the professor himself is working; but, as the scientific name and position of the professor depends, not only on his own work, but to a large extent on the work issuing from his laboratory, he is careful not to limit himself to too narrow a range of his science.

"Of course it is best of all if the student selects for himself a suitable 'theme,' suggested to him by his lectures or practical work, or from private study of the literature of the science. But this seldom happens, for the young student is not yet able to discern the bearing of special questions and lacks knowledge how to work them out. Sometimes (but not very often, indeed) he points out to his professor in a general way the kind of problems he would like to work at, and the professor suggests to him a special problem out of this range of subjects. During the working out of his chosen subject the student learns generally much more than he has heard at lectures. Every part of the investigation forces him to revise the scientific foundations of the operations he performs. During this time the incidental short lectures given by the professor on his daily round from one to another of the advanced students are most effective in deepening and strengthening the student's knowledge. As these explanatory remarks are generally heard, not only by the student whose work has caused them, but also by a number of fellow-students working near, a fairly wide range of scientific

questions are dealt with in their hearing. Often these small lectures develop themselves into discussions, and, as for myself, I judge from the frequency of such discussions between the students whether the session will turn out a good one or not. If the professor thinks the work sufficiently complete to be used as a dissertation, the student proceeds to the close of his studies. He prepares himself for the examination, which is conducted by the very professors whose lectures he has heard and in whose laboratories he has worked. This examination varies somewhat in different universities, but in no case is it either very long or extensive; indeed, it is not considered as very important. For we are all aware what an uncertain means of determining a man's knowledge and capabilities an examination is, and how much its issue depends upon accidental circumstances. Part of this uncertainty is removed by the fact that the professor and the pupil know each other, are acquainted with one another's modes of expression and scientific views. The main purpose of the examination is to induce the student to widen his knowledge to a greater extent than is covered by the subject of his dissertation; but, indeed, it happens very seldom that a student whose work is considered sufficient does not pass the examination.

"We have no great fear that this system may induce a professor to treat his own pupils in too lenient a way, and so lower the standard of the Doctor's degree. There was a time when such abuses used to occur, but there very soon arose such public indignation that the abuses ceased to occur. Even at the present day similar instances occasionally occur, but, as before remarked, the position of a professor depends in such a degree upon the value of the dissertations worked out under his supervision, that such deviations from the right way correct themselves in the course of time. The most effective instrument for that purpose is the publication of all dissertations and the consequent public control over them; for this reason publication is, I believe, compulsorily prescribed in all German universities.

"When the student has finished his course he is still entirely free to choose between a scientific and a technical career. This is a very important point in our educational system; it is made possible by the circumstance that the occupation of a technical chemist in works is very often almost as scientific in its character as in a university laboratory. This is connected with a remarkable feature in the development of technical chemistry in Germany—the very point upon which the important position of chemical manufacture in this country depends. The organisation of the power of invention in manufactures and on

a large scale is, as far as I know, unique in the world's history, and it is the very marrow of our splendid development. Each large works has the greater part of its scientific staff—and there are often more than 100 *doctores phil.* in a single manufactory—occupied, not in the management of the manufacture, but in making inventions. The research laboratory in such a work is only different from one in a university by its being more splendidly and sumptuously fitted than the latter. I have heard from the business managers of such works that they have not unfrequently men who have worked for four years without practical success; but if they know them to possess ability they keep them notwithstanding, and in most cases with ultimate success sufficient to pay the expenses of the former resultless years.

"It seems to me a point of the greatest importance that the conviction of the practical usefulness of a theoretical or purely scientific training is fully understood in Germany by the leaders of great manufactories. When, some years ago, I had occasion to preside at a meeting, consisting of about two-thirds practical men and one-third teachers, I was much surprised to observe the unhesitating belief of the former in the usefulness of entirely theoretical investigations. And I know a case where, quite recently, an "extraordinary" professor of a university has been offered a very large salary to induce him to enter a works, only for the purpose of undertaking researches regarding the practical use of some scientific methods which he had been working at with considerable success. No special instructions are given to him, for it is taken for granted that he himself will find the most promising methods; only, in order to increase his interest in the business, part of his remuneration has been made proportional to the commercial success of his future inventions. From this clear understanding of the commercial importance of science by the directors of industrial establishments there science itself gains another advantage. A scientific man can be almost sure, if he wants in his investigations the help of such technical means as only great works can afford, that he will get such assistance at once on application to any works, and the scientific papers of German chemists very often contain acknowledgments, with due thanks, of considerable help they have thus obtained.

"Besides these advantages for the development of scientific and technical chemistry in Germany there exists another very important factor—practical assistance from the Government. Universities are in Germany affairs of the State, not of the Empire, and in no other point has the division of the Fatherland into many smaller countries proved itself to such a degree a boon and a blessing. The essential

character of the German universities, the freedom conferred by the independence of the numerous universities, is never lost. There have been hard times occasionally for the universities of one country or another; but some universities were always to be found where even in times of hard oppression liberty of teaching and learning remained complete and unaffected, and the spirit of pure unalloyed scientific research was preserved and encouraged. So this palladium of intellectual freedom has never been lost; and it regained the former influence as soon as the casual oppression ceased. In our days, there is among all the separate State Governments in Germany a clear conviction of the importance of practical support being given to pure scientific research. To take one instance, in order to facilitate teaching and research in electro-chemistry (a recently developed branch of science) a suggestion by some leading practical scientific men to the members of the Government was sufficient. Upon such a suggestion a considerable sum of money was spent first by the Prussian Government for the endowment of electro-chemical chairs and laboratories in the three "polytechnic" colleges of that country. A short time afterwards it was resolved to erect at one of the universities (Göttingen) an institute for physical chemistry, and especially electro-chemistry, in the shape of a building which has just been completed. At the same time, other German countries have begun to grant to their universities and technical colleges considerable sums of money for similar purposes; *e.g.*, the Saxon Landtag alone has unanimously voted half a million marks (=£25,000) for the erection of a splendid laboratory for physical chemistry at Leipzig.

"You will excuse my boasting about our German management of this most important question of scientific education. It is no blind admiration without criticism, for I know by practical experience the management in other countries, and I can compare them. And it is only for the sake of science itself that I write these lines. If they should help the spread of the conviction of the incomparable practical usefulness of every support given to pure science, together with the recognition of the fact that the latter can only grow in an atmosphere of liberty and confidence, I should regard it as tending towards the progress of science itself, and destined to exercise such an influence upon scientific progress as may be compared with the discovery of the most remarkable scientific fact."]

A SHORT HISTORY OF SCIENTIFIC INSTRUCTION.*

(1898.)

The two addresses by my colleagues Profs. Judd and Roberts-Austen have drawn attention to the general history of our College and the details of one part of our organisation. I propose to deal with another part, the consideration of which is of very great importance at the present time, for we are in one of those educational movements which spring up from time to time and mould the progress of civilisation. The question of a teaching University in the largest city in the world, Secondary Education and so-called Technical Education are now occupying men's minds.

At the beginning it is imperative that I should call your attention to the fact that the stern necessities of the human race have been the origin of all branches of science and learning; that all so-called educational movements have been based upon the actual requirements of the time. There has never been an educational movement for learning's sake; but of course there have always been studies and students apart from any of those general movements to which I am calling attention; still we have

* An address delivered at the Royal College of Science on October 6, 1898.

to come down to the times of Louis Quatorze before the study of the useless, the *même inutile*, was recognised as a matter of national concern.

It is perhaps the more necessary to insist upon stern necessity as being the origin of learning, because it is so difficult for us now to put ourselves in the place of those early representatives of our race that had to face the problems of life among conditionings of which they were profoundly ignorant; when night meant death; when there was no certainty that the sun would rise on the morrow; when the growth of a plant from seed was unrecognised; when a yearly return of seasons might as well be a miracle as a proof of a settled order of phenomena; when, finally, neither cause nor effect had been traced in the operations of nature.

It is doubtless in consequence of this difficulty that some of the early races have been credited by some authors with a special love of abstract science, of science for its own sake; so that this, and not stern necessity, was the motive of their inquiries. Thus we have been told that the Chaldæans differed from the other early races in having a predilection for astronomy, another determining factor being that the vast plains in that country provided them with a perfect horizon.

The first historic glimpses of the study of astronomy we find among the peoples occupying the Nile Valley and Chaldæa, say 6000 B.C.

But this study had to do with the fixing of the length of the year, and the determination of those times in it in which the various agricultural operations had to be performed. These were related strictly to the rise of the Nile in one country and of the Euphrates in the other. All human

activity was in fact tied up with the movements of the sun, moon and stars. These, then, became the gods of those early peoples, and the astronomers, the seers, were the first priests; revered by the people because, as interpreters of the celestial powers, they were the custodians of the knowledge which was the most necessary for the purposes of life.

Eudemus of Rhodes, one of the principal pupils of Aristotle, in his History of Geometry, attributes the origin of geometry to the Egyptians, "who were obliged to invent it in order to restore the landmarks which had been destroyed by the inundation of the Nile," and observes "that it is by no means strange that the invention of the sciences should have originated in practical needs."* The new geometry was brought from Egypt to Greece by Thales three hundred years before Aristotle was born.

When to astronomy and geometry we add the elements of medicine and surgery, which it is known were familiar to the ancient Egyptians, it will be conceded that we are, in those early times, face to face with the cultivation of the most useful branches of science.

Now, although the evidence is increasing day by day that Greek science was Egyptian in its origin, there is no doubt that its cultivation in Greece was more extended, and that it was largely developed there. One of the most useful and prolific writers on philosophy and science who has ever lived, Aristotle, was born in the fourth century B.C. From him, it may be said, dates a general conception of science based on *observation* as differing from experiment. If you wish to get an idea of the science of those times, read his writings on Physics and on the Classification of Animals.

* "Greek Geometry from Thales to Euclid," p. 2. (Allman.)

All sought in Aristotle the basis of knowledge, but they only read his philosophy; Dante calls him "the Master of those who know."*

Why was Aristotle so careful to treat science as well as philosophy, with which his master, Plato, had dealt almost exclusively?

The answer to this question is of great interest to our present subject. The late Lord Playfair† in a pregnant passage, suggests the reason, and the later history of Europe shows, I think, that he is right.

> "We find that just as early nations became rich and prosperous, so did philosophy arise among them, and it declined with the decadence of material prosperity. In those splendid days of Greece, when Plato, Aristotle and Zeno were the representatives of great schools of thought which still exercise their influence on mankind, *Greece was a great manufacturing and mercantile community;* Corinth was the seat of the manufacture of hardware; Athens that of jewellery, shipbuilding and pottery. The rich men of Greece and all its free citizens were actively engaged in trade and commerce. The learned class were the sons of those citizens, and were in possession of their accumulated experience derived through industry and foreign relations. Thales was an oil merchant; Aristotle inherited wealth from his father, who was a physician, but, spending it, is believed to have supported himself as a druggist till Philip appointed him tutor to Alexander. Plato's wealth was largely derived from commerce, and his master, Socrates, is said to have been a sculptor. Zeno, too, was a travelling merchant. Archimedes is perhaps an exception, for he is said to have been closely related to a prince; but if so, he is the only princely discoverer of science on record."

In ancient Greece we see the flood of the first great intellectual tide. Alas! it never touched the shores of Western Europe, but it undoubtedly reached to Rome, and there must have been very much more observational science taught in the Roman studia than we generally

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* "Inferno," c. iv. 130 *et seq.*

† "Subjects of Social Welfare," p. 206.

imagine, otherwise how explain the vast public works, and their civilising influence carried over sea and land from Africa to Scotland? In some directions their applications of science are as yet unsurpassed.

With the fall of the Roman Empire both science and philosophy disappeared for a while. The first wave had come and gone; its last feebler ripples seem to have been represented at this time by the gradual change of the Roman secular studia wherever they existed into clerical schools, the more important of which were in time attached to the chief cathedrals and monasteries; and it is not difficult to understand why the secular (or scientific) instruction was gradually replaced by one more fitted for the training of priests.

It is not to be wondered at that the ceaseless strife in the centre of Europe had driven what little learning there was to the western and southern extremities where the turmoil was less—I refer to Britain and South Italy—while the exiled Nestorians carried Hellenic science and philosophy out of Europe altogether to Mesopotamia and Arabia.

The next wave, it was but a small one, had its origin in our own country. In the eighth century England was at its greatest height, relatively, in educational matters; chiefly owing to the labours of two men. Beda, generally called the Venerable Bede, the most eminent writer of his age, was born near Monkwearmouth in 673, and passed his life in the monastery there. He not only wrote the history of our island and nation, but treatises on the nature of things, astronomy, chronology, arithmetic, medicine, philosophy, grammar, rhetoric, poetry, music;

basing his work on that of Pliny. He died in 735, in which year his great follower was born in Yorkshire. I refer to Alcuin. He was educated at the Cathedral School at York under Archbishop Egbert, and having imbibed everything he could learn from the writings of Bede and others, was soon recognised as one of the greatest scholars of the time. On returning from Rome, whither he had been sent by Eaubald to receive the pallium, he met Karl the Great, King of the Franks and Lombards, who eventually induced him to take up his residence at his Court, to become his instructor in the sciences. Karl (or Charlemagne) then was the greatest figure in the world, and although as King of the Franks and Lombards, and subsequently Emperor of the Holy Roman Empire, his Court was generally at Aachen, he was constantly travelling throughout his dominions. He was induced, in consequence of Alcuin's influence, not only to have a school always about him on his journeys, but to establish, or foster, such schools wherever he went. Hence it has been affirmed that "France is indebted to Alcuin for all the polite learning it boasted of in that and the following ages." The Universities of Paris, Tours, Fulden, Soissons and others were not actually founded in his day, but the monastic and cathedral schools out of which they eventually sprung were strengthened, and indeed a considerable scheme of education for priests was established; that is, an education free from all sciences and in which philosophy alone was considered.

Karl the Great died in 814, and after his death the eastward travelling wave, thus started by Bede and Alcuin, slightly but very gradually increased in height. Two centuries later, however, the conditions were changed.

We find ourselves in presence of interference phenomena, for then there was a meeting with another wave travelling westwards, and this meeting was the origin of the European Universities. The wave now manifested travelling westerly, spread outward from Arab centres first and finally from Constantinople, when its vast stores of Greek lore were opened by the conquest of the city.

The first wavelet justified Eudemus' generalisation that "the invention of the Sciences originated in practical needs," and that knowledge for its own sake was not the determining factor. The year had been determined, stone circles erected almost everywhere, and fires signalled from them, giving notice of the longest and shortest days, so that agriculture was provided for, even away from churches and the Festivals of the Church. The original user of geometry was not required away from the valleys of the Nile, Tigris and Euphrates, and, therefore, it is now Medicine and Surgery that come to the front for the alleviation of human ills. In the eleventh century we find Salerno, soon to be famed throughout Europe as the great Medical School, forming itself into the first University. And Medicine did not exhaust all the science taught, for Adelard listened there to a lecture on "the nature of things," the cause of magnetic attraction being one of the "things" in question.

This teaching at Salerno preceded by many years the study of the law at Bologna and of theology at Paris.

The full flood came from the disturbance of the Arab wave centre by the Crusades, about the beginning of the eleventh century. After the Pope had declared the "Holy War," William of Malmesbury tells us:

"The most distant islands and savage countries were inspired with

this ardent passion. The Welshman left his hunting, the Scotchman his fellowship with vermin, the Dane his drinking party, the Norwegian his raw fish."

Report has it that in 1096 no less than 6,000,000 were in motion along many roads to Palestine. This, no doubt, is an exaggeration, but it reflects the excitement of the time, and prepares us for what happened when the Crusaders returned; as Green puts it* :—

"The western nations, including our own, 'were quickened with a new life and throbbing with a new energy.' . . . . A new fervour of study sprang up in the West from its contact with the more cultured East. Travellers like Adelard, of Bath, brought back the first rudiments of physical and mathematical science from the schools of Cordova or Bagdad. . . . The long mental inactivity of feudal Europe broke up like ice before a summer's sun. Wandering teachers, such as Lanfranc or Anselm, crossed sea and land to spread the new power of knowledge. The same spirit of restlessness, of inquiry, of impatience with the older traditions of mankind, either local or intellectual, that drove half Christendom to the tomb of its Lord, crowded the roads with thousands of young scholars hurrying to the chosen seats where teachers were gathered together."

Studium generale was the term first applied to a large educational centre where there was a guild of masters, and whither students flocked from all parts. At the beginning of the thirteenth century the three principal studia were Paris, Bologna and Salerno, where theology and arts, law and medicine, and medicine almost by itself, were taught respectively; these eventually developed into the first universities.†

English scholars gathered in thousands at Paris round the chairs of William of Champeaux and Abelard, where they took their place as one of the "nations" of which the great Middle Age University of Paris was composed.

* "History of the English People," I. 198.
† See "Histoire de l'Université de Paris." Crévier, 1791, *passim.*

We have only to do with the Arts faculty of this University. We find that the subject-matter of the liberal education of the Middle Ages, there dealt with, varied very little from that taught in the schools of ancient Rome.

The so-called "artiens," students of the Arts faculty which was the glory of the University and the one most numerously attended, studied the seven arts of the trivium and quadrivium—that is, grammar, rhetoric, dialectic; and arithmetic, geometry, music, astronomy.*

This at first looks well for scientific study, but the mathematics taught had much to do with magic; arithmetic dealt with epacts, golden numbers and the like. There was no algebra and no mechanics. Astronomy dealt with the system of the seven heavens.

Science, indeed, was the last thing to be considered in the theological and legal studia, and it would appear that it was kept alive more in the medical schools than in the Arts faculties. Aristotle's writings on physics, biology and astronomy were not known till about 1230, and then in the shape of Arab-Latin translations. Still it must not be forgotten that Dante learned some of his astronomy, at all events, at Paris.

Oxford was an offshoot of Paris, and therefore a theological studium, in all probability founded about 1167,† and Cambridge came later.

Not till the Reformation (sixteenth century) do we see any sign of a new educational wave, and then we find the two which have had the greatest influence upon the

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* Enumerated in the following Middle Age Latin verse:

"Lingua, tropus, ratio, numerus, tonus, angulus, astra."

† "Universities of Europe in the Middle Ages," Rashdall, vol. ii. p. 344.

history of the world—one of them depending upon the Reformation itself, the other depending upon the birth of experimental inquiry.

Before the Reformation the Universities were priestly institutions and derived their authority from the Popes.

The Universities were for the few; the education of the people, except in the various crafts, was unprovided for.

The idea of a general education in secular subjects at the expense of the State or of communities is coeval with the Reformation. In Germany, even before the time of Luther, it was undreamt of, or rather, perhaps, one should say, the question was decided in the negative. In his day, however, his zeal first made itself heard in favour of education, as many are now making themselves heard in favour of a better education; and in 1524 he addressed a letter to the Councils of all the towns in Germany, begging them "to vote money not merely for roads, dikes, guns and the like, but for schoolmasters, so that the poor children might be taught; on the ground that if it be the duty of a State to compel the able-bodied to carry arms, it is *à fortiori* its duty to compel its subjects to send their children to school."*

Here we have the germ of Germany's position at the present day, not only in scientific instruction but in everything which that instruction brings with it.

With the Reformation this idea spread to France. In 1560 we find the States General of Orleans suggesting to Francis II. a—

"Levée d'une contribution sur les bénéfices ecclésiastiques pour raisonablement stipendier des pédagogues et gens lettrés, en toutes villes et villages, pour l'instruction de la pauvre jeunesse du plat pays,

* This is a quotation from my Coventry address, see p. 28.

et soient tenus les pères et mères, à peine d'amende, à envoyer les dits enfants à l'école, et à ce faire soient contraints par les segnieurs et les juges ordinaires."

Two years after this suggestion, however, the religious wars broke out ; the material interests of the clerical party had predominated, the new spirit was crushed under the iron heel of priestcraft, and the French, in consequence, had to wait for three centuries and a revolution before they could get comparatively free.

In the Universities, or at all events alongside them, we find next the introduction, not so much of science with its experimental side as we now know it, as of the scientific spirit.

The history of the Collége de France, founded in 1531 by Francis the First, is of extreme interest. In the fifteenth century the studies were chiefly literary, and except in the case of a few minds they were confined merely to scholastic subtleties, taught (I have it on the authority of the Statistique de l'Enseignement Supérieur) in barbarous Latin. This was the result of the teaching of the faculties ; but even then, outside the faculties, which were immutable, a small number of distinguished men still occupied themselves in a less rigid way in investigation ; the studies, however, were chiefly literary. Among those men may be mentioned Danès, Postel, Dole, Guillaume Budé, Lefèvre d'Étaples and others, who edited with notes and commentaries Greek and Latin authors whom the University scarcely knew by name. Hence the renaissance of the sixteenth century, which gave birth to the Collège de France, the function of which, at the commencement, was to teach those things which were not in the ordinary curriculum of the faculties of the university. It was called the *Collège des Deux Langues*,

the languages being Hebrew and Greek. It then became the *Collège des Trois Langues*, when the king, notwithstanding the opposition of the University, created in 1534 a chair of Latin. There was another objection made by the University to the new creation; from the commencement the courses were free; and this feeling was not decreased by the fact that around the celebrated masters of the Trois Langues a crowd of students was soon congregated.

The idea in the mind of Francis the First in creating this Royal College may be gathered from the following Edict, dated in 1545:—

"François, etc., savoir faisons à tous présents et à venir que Nous, considérant que le sçavoir des langues, qui est un des dons du Saint-Esprit, fait ouverture et donne le moyen de plus entière connaissance et plus parfaite intelligence de toutes bonnes, honnêtes, saintes et salutaires sciences. . . . Avons fait faire pleinement entendre à ceux qui, y voudraient vacquer, les trois langues principales, Hébraïque, Grecque, et Latine, *et les Livres esquels les bonnes sciences* sont le mieux et le plus profondément traitées. A laquelle fin, et en suivant le décret du concile de Vienne, nous avons piéça ordonné et establi en nôtre bonne ville de Paris, un bonne nombre de personnages de sçavoir excellent, qui lisent et enseignent publiquement et ordinairement les dites langues et sciences, maintenant florissant autant ou plus qu'elles ne firent de bien longtemps. . . . auxquels nos lecteurs avons donné honnêtes gages et salaires, et iceux fait pourvoir de plusieurs beaux bénéfices pour les entretenir et donner occasion de mieux et plus continuellement entendre au fait de leur charge. . . . etc."

The Statistique, which I am following in this account, thus sums up the founder's intention:—

"Le Collège Royal avait pour mission de propager les nouvelles connaissances, les nouvelles découvertes. Il n'enseignait pas la science faite, il la faisait."

It was on account of this, more than on account of anything else, that it found its greatest enemy in the

University. The founding of this new College, and the great excitement its success occasioned in Paris, were, there can be little doubt, among the factors which induced Gresham to found his College in London in 1574. These two institutions and the street trading which preceded the buildings played a great part in their time. Gresham College, it is true, was subsequently strangled, but not before its influence had been such as to permit the Royal Society to rise phœnix-like from its ashes, for it is on record that the first step in the forming of this Society was taken after a lecture on astronomy by Sir Christopher Wren at the College. All connected with the two institutions felt the change of thought in the century which saw the birth of Bacon, Galileo, Gilbert, Hervey, Tycho Brahe, Descartes and many others that might be named ; and of these, it is well to remark, Gilbert,* Hervey and Galileo were educated in medical schools abroad.

Bacon was not only the first to lay down *regulæ philosophandi*, but he insisted upon the far-reaching results of research, not forgetting to point out that "*lucifera experimenta, non fructifera quærenda,*"† as a caution to the investigator, though he had no doubt as to the revolution about to be brought about by the ultimate application of the results of physical inquiry.

As early as 1560 the Academia Secretorum Naturæ was founded at Naples, to be followed by the Lincei in 1609, the Royal Society in 1645, the Cimento in 1657 and the Paris Academy in 1666.

From that time the world may be said to have belonged

* "William Gilbert, of Colchester, on the Magnet." Mittelag, p. x.
† "Nov. Org.," 1. 70. Fowler's Edition, p. 255.

to science, now no longer based merely on observation but on experiment. But, alas! how slowly has it percolated into our Universities.

The first organised endeavour to teach science in schools was naturally made in Germany (Prussia), where, in 1747 (nearly a century and a half ago), Realschulen were first started; they were taken over by the Government in 1832 and completely reorganised in 1859, this step being demanded by the growth of industry and the spread of the modern spirit. Eleven hours a week were given to natural science in these schools forty years ago.

Teaching the Teachers.

Until the year 1762 the Jesuits had the education of France almost entirely in their hands, and when, therefore, their expulsion was decreed in that year, it was quite a necessary step to create an institution to teach the future teachers of France. Here, then, we had the École Normale in theory; but it was a long time before this theory was carried into practice, and very probably it would never have been, had not Rolland d'Erceville made it his duty, for more than twenty years, by numerous publications, amongst which is especially to be mentioned his "Plan d'Education," printed in 1783, to point out, not merely the utility, but the absolute necessity for some institution of the kind. As generally happens in such cases, this exertion was not lost, for, in 1794, it was decreed that an *École Normale* should be opened at Paris :—

"Où seront appelés de toutes les parties de la République, des citoyens déjà instruits dans les sciences utiles, pour apprendre, sous les professeurs les plus habiles dans tous les genres, l'art d'enseigner."

To follow these courses in the art of teaching, one potential schoolmaster was to be sent to Paris by every district containing 20,000 inhabitants. 1,400 or 1,500 young men, therefore, arrived in Paris, and in 1795 the courses of the school were opened first of all in the amphitheatre of the Museum of Natural History. The professors were chosen from among the most celebrated men of France, the sciences being represented by Lagrange, Laplace, Haüry, Monge, Daubenton and Berthollet.

While there was this enormous progress abroad, represented especially by the teaching of science in Germany and the teaching of the teachers in France, things slumbered and slept in Britain. We had our coal and our iron, and no one troubled about an improved education—least of all the universities, which had become, according to Matthew Arnold (who was not likely to overstate matters), mere *hauts lycées*, and "had lost the very idea of a real university,"* and since our political leaders generally came from the universities little more was to be expected from them.

Many who have attempted to deal with the history of education have failed to give sufficient prominence to the tremendous difference there must necessarily have been in scientific requirements before and after the introduction of steam power.

It is to the discredit of our country that we, who gave the perfected steam engine, the iron ship and the locomotive to the world, should have been the last to feel the next wave of intellectual progress.

All we did at the beginning of the century was to found mechanics' institute. They knew better in Prussia,

* "Schools and Universities on the Continent," p. 291.

"a bleeding and lacerated mass,"* after Jena (1806), King Frederic William III. and his councillors, disciples of Kant, founded the University of Berlin, "to supply the loss of territory by intellectual effort." In spite of the universal poverty, money was given for the improvement or extension of the Universities of Kœnigsberg and Breslau, and that of Bonn was founded in 1818. As a result of this policy, carried on persistently and continuously by successive ministers, aided by wise councillors, many of them the products of this policy, such a state of things was brought about that not many years ago M. Ferdinand Lot, one of the most distinguished educationists of France, accorded to Germany "a supremacy in Science comparable to the supremacy of England at sea."

But this position has not been obtained merely by founding new universities. To Germany we owe the perfecting of the methods of teaching Science.

I have shown that it was in Germany that we find the first organised science teaching in schools. About the year 1825 that country made another tremendous stride. Liebig demonstrated that science teaching, to be of value, whether in the school or the university, must consist to a greater or less extent in practical work, and the more the better; that book work was next to useless.

Liebig, when appointed to Giessen, smarting still under the difficulties he had had in learning chemistry without proper appliances, induced the Darmstadt Government to build a chemical laboratory in which the students could receive a thorough practical training.

* "University Education in England, France and Germany," Sir Rowland Blennerhassett, p. 25.

It will have been gathered from this reference to Liebig's system of teaching chemistry, that still another branch of applied science had been created, which has since had a stupendous effect upon industry; and while Liebig was working at Giessen, another important industry was being created in England. I refer to the electric telegraph and all its developments, foreshadowed by Galileo in his reference to the "sympathy of magnetic needles."

Not only then in chemistry but in all branches of science which can be applied to the wants of man, the teaching must be practical—that is, the student must experiment and observe for himself and he must himself seek new truths.

It was at last recognised that a student could no more learn Science effectively by seeing some one else perform an experiment than he could learn to draw effectively by seeing some one else make a sketch. Hence in the German Universities the Doctor's degree is based upon a research.

Liebig's was the *fons et origo* of all our laboratories—mechanical, metallurgical, chemical, physical, geological, astronomical and biological.

I must come back from this excursion to call your attention to the year 1845, in which one of the germs of our College first made its appearance.

What was the condition of England in 1845? Her universities had degenerated into *hauts lycées*. With regard to the University teaching, I may state that even as late as the late fifties a senior wrangler—I had the story from himself—came to London from Cambridge expressly to walk about the streets to study crystals, prisms, and the like in the opticians' windows. Of

laboratories in the universities there were none; of science teaching in the schools there was none; there was no organisation for training science teachers.

If an artisan wished to improve his knowledge he had only the moribund Mechanics' Institutes to fall back upon.

The nation which then was renowned for its utilisation of waste material products allowed its mental products to remain undeveloped.

There was no minister of instruction, no councillors with a knowledge of the national scientific needs, no organised secondary or primary instruction. We lacked then everything that Germany had equipped herself with in the matter of scientific industries.

Did this matter? Was it more than a mere abstract question of a want of perfection?

It mattered very much! From all quarters came the cry that the national industries were being undermined in consequence of the more complete application of scientific methods to those of other countries.

The chemical industries were the first to feel this, because England was then the seat of most of the large chemical works.*

Very few chemists were employed in these chemical works. There were in some cases so-called chemists at about bricklayers' wages, not much of an inducement to study chemistry, even if there had been practical laboratories where it could have been properly learnt. Hence when efficient men were wanted they were got from abroad, *i.e.*, from Germany, or the richer English had to go abroad themselves.

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* Perkin, *Nature*, xxxii. 334.

Fortunately for us, at this time, we had in England, in very high place, a German fully educated by all that could be learned at one of the best equipped modern German Universities, where he had studied both science and the fine arts. I refer to the Prince Consort. From that year to his death he was the fountain of our English educational renaissance, drawing to himself men like Playfair, Clark and De la Beche; knowing what we lacked, he threw himself into the breach. This College is one of the many things the nation owes to him. His service to his adopted country, and the value of the institutions he helped to inaugurate, are by no means even yet fully recognised, because those from whom national recognition, full and ample, should have come, were, and to a great extent still are, the products of the old system of middle age scholasticism which his clear vision recognised was incapable by itself of coping with the conditions of modern civilised communities.

It was in the year 1845 that the influence of the Prince Consort began to be felt. Those who know most of the conditions of Science and Art then and now, know best how beneficial that influence was in both directions; my present purpose, however, has only reference to Science.

The College of Chemistry was founded in 1845, first as a private institution; the School of Mines was established by the Government in 1851.

In the next year, in the speech from the Throne at the opening of Parliament, Her Majesty spoke as follows:—

"The advancement of the Fine Arts and of practical Science will be readily recognised by you as worthy the attention of a great and enlightened nation. I have directed that a comprehensive scheme shall be laid before you having in view the promotion of these objects, towards which I invite your aid and co-operation."

Strange words these from the lips of an English sovereign!

The Government of this country was made at last to recognise the great factors of a peaceful nation's prosperity, and to reverse a policy which has been as disastrous to us as if they had insisted upon our naval needs being supplied by local effort as they were in Queen Elizabeth's time.

England has practically lost a century; one need not be a prophet to foresee that in another century's time our education and our scientific establishments will be as strongly organised by the British Government as the navy itself.

As a part of the comprehensive scheme referred to by Her Majesty, the Department of Science and Art was organised in 1853, and in the amalgamation of the College of Chemistry and the School of Mines we have the germ of our present institution.

But this was not the only science school founded by the Government. The Royal School of Naval Architecture and Marine Engineering was established by the Department at the request of the Lords Commissioners of the Admiralty, "with a view of providing especially for the education of shipbuilding officers for Her Majesty's Service, and promoting the general study of the Science of Ship Building and Naval Engineering." It was not limited to persons in the Queen's Service, and was opened on November 1, 1864. The present Royal College of Science was built for it and the College of Chemistry. In 1873 the School was transferred to the Royal Naval College, Greenwich, and this accident enabled the teaching from Jermyn Street to be transferred

and proper practical instruction to be given at South Kensington. The Lords of the Admiralty expressed their entire satisfaction with the manner in which the instruction had been carried on at South Kensington; and well they might, for in a memorandum submitted to the Lord President in 1887, the President and Council of the Institute of Naval Architects state:—

> "When the department dealt with the highest class of education in Naval Architecture by assisting in founding and by carrying on the School of Naval Architecture at South Kensington, the success which attended their efforts was phenomenal, the great majority of the rising men in the profession having been educated at that Institution."

Here I again point out, both with regard to the School of Mines, the School of Naval Architecture and the later Normal School, that it was stern need that was in question, as in Egypt in old times.

Of the early history of the College I need say nothing after the addresses of my colleagues, Profs. Judd and Roberts-Austen, but I am anxious to refer to some parts of its present organisation and their effect on our national educational growth in some directions.

It was after 1870 that our institution gradually began to take its place as a Normal School—that is, that the teaching of teachers formed an important part of its organisation, because in that year the newly-established Department, having found that the great national want then was teachers of Science, began to take steps to secure them. Examinations had been inaugurated in 1859, but they were for outsiders, conferring certificates and a money reward on the most competent teachers tested in this way. These examinations were really controlled by our School, for Tyndall, Hofmann, Ramsay, Huxley,

and Warington Smyth, the first professors, were also the first examiners.

Very interesting is it to look back at that first year's work, the first cast of the new educational net. After what I have said about the condition of Chemistry and the establishment of the College of Chemistry in 1845, you will not be surprised to hear that Dr. Hofmann was the most favoured—he had forty-four students.

Prof. Huxley found one student to tackle his questions, and he failed.

Profs. Ramsay and Warington Smyth had three each, but the two threes only made five; for both lists were headed by the name of

Judd, John W.,
Wesleyan Training College,
Westminster.

Our present Dean was caught in the first haul.

These examinations were continued till 1866, and upwards of 600 teachers obtained certificates, some of them in several subjects.

Having secured the teachers, the next thing the Department did was to utilise them. This was done in 1859 by the establishment of the Science Classes throughout the country which are, I think, the only part of our educational system which even the Germans envy us. The teaching might go on in schools, attics or cellars; there was neither age-limit nor distinction of sex or creed.

Let me insist upon the fact that from the outset practical work was encouraged by payments for apparatus, and that latterly the examinations themselves, in some of the subjects, have been practical.

The number of students under instruction in Science

Classes organized by the Department in the first year these classes were held was 442; the number in 1897 was 202,496. The number of candidates examined in the first year in which local examinations were held was 650, who worked 1,000 papers; in 1897 the number was 106,185, who worked 159,724 papers, chemistry alone sending in 28,891 papers, mathematics 24,764 and physiography 16,879.

The total number of individual students under instruction in Science Classes under the Department from 1859 to 1897 inclusive has been, approximately, 2,000,000. Of these about 900,000 came forward for examination, the total number of papers worked by them being 3,195,170.

Now why have I brought these statistics before you?

Because from 1861 onwards the chief rewards of the successful students have been scholarships and exhibitions held in this College; a system adopted in the hope that in this way the numbers of perfectly trained Science Teachers might be increased, so that the Science Classes throughout the country might go on from strength to strength.

The Royal Exhibitions date from 1863, the National Scholars from 1884. The Free Studentships were added later.

The strict connection between the Science Classes throughout the country and our College will be gathered from the following statement, which refers to the present time:—

Twenty-one Royal Exhibitions—seven open each year—four to the Royal College of Science, London, and three to the Royal College of Science, Dublin.

Sixty-six National Scholarships—twenty-two open each

year—tenable, at the option of the holder, at either the Royal College of Science, London, or the Royal College of Science, Dublin.

Eighteen Free Studentships—six open each year—to the Royal College of Science, London.

A Royal Exhibition entitles the holder to free admission to lectures and laboratories, and to instruction during the course for the Associateship—about three years—in the Royal College of Science, London, or the Royal College of Science, Dublin, with maintenance and travelling allowances.

A National Scholarship entitles the holder to free admission to lectures and laboratories and to instruction during the course of the Associateship—about three years—at either the Royal College of Science, London, or the Royal College of Science, Dublin, at the option of the holder—with maintenance and travelling allowances.

A Free Studentship entitles the holder to free admission to the lectures and laboratories and to instruction during the course for the Associateship—about three years—in the Royal College of Science, London, but not to any maintenance or travelling allowance.

Besides the above students who have been successful in the examinations of the Science Classes, a limited number (usually about sixty) of teachers and of students in science classes who intend to become science teachers, are admitted free for a term or session to the courses of instruction. They may be called upon to pass an entrance examination. Of these, there are two categories—those who come to learn for a short time and those who remain longer to teach; some of the latter may be associates.

Besides all these, those holding Whitworth Scholarships

and Exhibitions—the award of which is decided by the Science examinations—can, and some do, spend the years covered by them at the College.

In this way, then, is the École Normale side of our institution built up.

The number of Government students in the College in 1872 was twenty-five, in 1886 it was 113 and in 1897 it was 186.

The total number of students who passed through the College from 1882–83 to 1896 inclusive was 4,145. Of these 1,966 were Government students. The number who obtained the Associateship of the Royal School of Mines from 1851 to 1881 was 198, of whom thirty-nine were Government students, and of the Royal College of Science and Royal School of Mines from 1882 to 1897 the number was 525, of whom 323 were Government students. Of this total of 362 Government students ninty-four were Science teachers in training.

With regard to the Whitworth Scholarships, which, like the Exhibitions, depend upon success at the yearly examinations throughout the country, I may state that six have held their scholarships at the College for at least a part of the scholarship period, and three others were already associates.

So much for the prizemen we have with us. I next come to the teachers in training who come to us. The number of teachers in training who have passed through the College from 1872 to 1897 inclusive is about 600 ; on an average they attended about two years each. The number in the session 1872–73, when they were first admitted, was sixteen, the number in 1885–86 was fifty and in 1896–97 sixty. These have not as a rule taught

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Science Classes previously, but before admission they give an undertaking that they intend to teach. In the earlier years some did not carry out this undertaking, doubtless because of the small demand for teachers of Science at that time. But we have changed all that. With but very few exceptions, all the teachers so trained now at once begin teaching, and not necessarily in classes under the Department. It is worthy of note, too, that many Royal Exhibitioners and National Scholars, although under no obligation to do so, also take up Science teaching. It is probable that of all the Government students now who pass out of the College each year not less than three-fourths become teachers. The total number of teachers of Science engaged in classes under the Department alone at the present time is about 6,000.

I have not yet exhausted what our College does for the national efforts in aiding the teaching of Science.

When you, gentlemen, leave us about the end of June for your well-earned holidays, a new task falls upon your professors in the shape of summer courses to teachers of Science Classes brought up by the Department from all parts of the four kingdoms to profit by the wealth of apparatus in the College and Museum, and the practical work which it alone renders possible.

The number of Science teachers who have thus attended the summer courses reaches 6,200, but as many of these have attended more than one course the number of separate persons is not so large.

Research.

From time to time balances arise in the Scholarship fund owing to some of the National Scholarships or Royal

Exhibitions being vacated before the full time for which they are tenable has expired. Scholarships are formed from these balances and awarded among those students who, having completed the full course of training for the Associateship, desire to study for another year at the College. *It is understood that the fourth year is to be employed in research in the subject of the Associateship.*

The gaining of one of the Remanet Scholarships, there are not more than two on the average annually, furnishes really the only means by which deserving students are enabled to pursue research in the College; as, although a professor has the power to nominate a student to a free place in his laboratory, very few of the most deserving students are able to avail themselves of the privilege owing to want of means.

The Department very rarely sends students up as teachers in training for research work, but only those who intend making teaching their profession are eligible for these studentships.

I trust that at some future day, when we get our new buildings—it is impossible to do more than we do till we get them—more facilities for research may be provided, and even an extension of time allowed for it, if necessary. I see no reason why some of the 1851 Exhibition Scholarships should not be awarded to students of this College, but to be eligible they must have published a research. Research should naturally form part of the work of the teachers in training who are not brought up here merely to effect an economy in the teaching staff.

Such, then, in brief, are some of our Normal School attributes. I think any one who knows the facts must acknowledge that the organisation has justified itself not

only by what it has done, but also by the outside activities it has set in motion. It is true that with regard to the system of examining school candidates by means of papers sent down from London, the Department was anticipated by the College of Preceptors in 1853, and by Oxford and Cambridge in 1858; but the action of 1861, when Science Classes were opened to everybody, was copied by Oxford and Cambridge in 1869. The Department's teachers got to work in 1860, but the so-called "University Extension Movement" dates only from 1873, and only quite recently have summer courses been started at Oxford and Cambridge.

The chemical and physical laboratories, small though they were in the Department's schools, were in operation long before any practical work in these subjects was done either at Oxford or Cambridge. When the College laboratories began about 1853, they existed practically alone. From one point of view we should rejoice that they are now third rate. I think it would be wrong of me not to call your attention to the tenacity, the foresight, the skill, the unswerving patience, exhibited by those upon whom has fallen the duty of sailing the good ship "Scientific Instruction," launched, as I have stated, out upon a sea which was certain from the history I have brought before you to be full of opposing currents.

I have had a statement prepared showing what the most distinguished of our old students and of those who have succeeded in the Department's examinations are now doing. The statement shows that those who have been responsible for our share in the progress of scientific instruction have no cause to be ashamed.

Conclusion.

I have referred previously to the questions of Secondary Education and of a true London University, soon, let us hope, to be realised.

Our College will be the first institution to gain from a proper system of Secondary Education, for the reason that scientific studies gain enormously by the results of literary culture, without which we can neither learn so thoroughly nor teach so effectively as one could wish.

To keep a proper mind-balance, engaged as we are here continuously in scientific thought, literature is essential, as essential as bodily exercise, and if I may be permitted to give you a little advice, I should say organise your athletics as students of the College, and organise your literature as individuals. I do not think you will gain so much by studying scientific books when away from here as you will by reading English and foreign classics, including a large number of works of imagination; and study French and German also in your holidays by taking short trips abroad.

With regard to the University. If it be properly organised, in the light of the latest German experience, with complete Science and Technical Faculties of the highest order, it should certainly insist upon annexing the School of Mines portion of our institution; the past history of the school is so creditable that the new University for its own sake should insist upon such a course. It would be absurd, in the case of a nation which depends so much on mining and metallurgy, if these subjects were not taught in the chief national University, as the University of London must become.

But the London University, like the Paris University,

if the little history of Science teaching I have given you is of any value, must leave our Normal College alone, at all events till we have more than trebled our present supply of science teachers.

But while it would be madness to abolish such an institution as our Normal School, and undesirable if not impossible to graft it on the new University, our school, like its elder sister in Paris, should be enabled to gain by each increase in the teaching power of the University. The students on the scientific side of the Paris School, in spite of the fact that their studies and researches are looked after by fourteen professors entitled Maîtres de Conférences, attend certain of the courses at the Sorbonne and the Collége de France, and this is one of the reasons why many of the men and researches which have enriched French science, hail from the École Normale.

One word more. As I have pointed out, the French École Normale was the result of a revolution; I may now add that France since Sedan has been doing, and in a tremendous fashion, what, as I have told you, Prussia did after Jena. Let us not wait for disastrous defeats, either on the field of battle or of industry, to develop to the utmost our scientific establishments and so take our proper and complete place among the nations.

SCIENTIFIC EDUCATION AND THE PROGRESS OF NATIONS.

(1899.)

There can be no doubt that in the future history of the world, for thousands of years, the century that is so rapidly passing away will be recorded as one of the most memorable, if not *the* most memorable, to which attention can be drawn. This high position will be awarded to it on the ground that it is the one which has most profoundly affected the life-conditions of the human race.

The salient point about the 19th century is that it is ? the *scientific century*. Theology, art, learning in the ordinary sense, are at the end of it pretty much as they were at the beginning; they have undergone no great development; but the applications of science have entirely changed, and for the better, the conditions of human life.

How comes it then that after living so many thousands of years upon the planet, for thanks to scientific explorations in Egypt and Babylonia we can now claim at least 10,000 years of more or less civilised communities, man has thus so suddenly come into so great a heritage ?

It must be conceded, when we come to look back upon our past history, that it is really very remarkable that

this question should arise. A volume would be required to answer it fully; let me content myself, as my space is limited, by referring to two or three instances in which Science, that is, the study of Nature and Nature's ways by either experiment or observation, was checked in a way which to us now seems almost inconceivable.

The evidence is now complete that both in Babylonia and Egypt in remote ages, the observation of the heavenly bodies was carried on with great assiduity, not from a love of pure science, but because a knowledge of the movements of the Sun, Moon and Stars was essential for the affairs of daily life and especially of agriculture. The young science soon found itself smothered and all but killed in a rank overgrowth of priestcraft and superstition, astrology being one of the forms of the latter; the difficulties with which the earliest students of nature found themselves surrounded can therefore be well imagined. Still the cult grew slowly and in the 4th century B.C. we find in Greece, into which land Egyptian science had penetrated in spite of all obstacles, one of the greatest masters of science who has ever lived, when his time is taken into account; from whom the world first gathered a general conception of science, as based on observation, the time of experiments was scarcely yet. I refer to Aristotle. It would have been better for the world if he had only been a student of science, but, splendidly universal in his thirst for and acquisition of knowledge, he wrote on philosophy as well. Science was a newer departure, and Greek Science enshrined in Aristotle's many treatises undoubtedly reached Rome. There must have been much more science taught in the Roman schools than we generally imagine, otherwise

how is it possible to account for the writings of Pliny, and vast public works, carried over sea and land from beyond Bab-el-Mandeb to our own shores.

However this may have been, the time of science was not yet, for schools and everything else went under in the fall of the Empire.

Was her chance taken at the Revival of Learning? When, about the 12th century, one after the other, the Universities of Salerno, Bologna, Paris, Oxford and Cambridge were founded? Alas no! At all these teaching centres, which were controlled by the Church, the masters and students alike sought in the writings of Aristotle the basis of knowledge, but his scientific treatises were unread, only his philosophy was studied; the whole world of natural phenomena was passed over by the many, although it was the secret study of the few.

It was never dreamed by the educational authorities that the study of such phenomena could by any possibility either expand the mind or materially aid the progress of mankind, while it was possible it might undermine faith. Hence it was practically left on one side.

We have to wait till the times of Galileo, Bacon, Gilbert, Hervey and others for a real beginning to be made, and in the direction which chiefly concerns us; and we all know that what happened to Galileo at the hands of the priestly authorities of his time was not calculated to foster the study of science. Bacon insisted upon the far-reaching results of research, having no doubt as to the revolution to be ultimately brought about by the application of the results of physical inquiry.

But it is less to Bacon and Descartes than to Luther

that we owe the final emancipation and development of scientific study; the development, however, was very slow.

Science was not taught on an organised plan in schools till 1747 when a beginning was made in Germany. The perfecting of our modern methods of teaching science both in schools and colleges we also owe to Germany. The work began here in earnest in 1845, and for this we have to thank chiefly the influence of the Prince Consort.

Here then may end our short history of the slow growth of the scientific spirit, and of some of the causes of it. There have always been students of science and their number has constantly increased, but their influence on the mass of mankind has been inappreciable chiefly in consequence of the opposition of the clerical authorities and of the educational systems in vogue.

Of one thing we may be now assured, the history of Egypt, Greece and Rome will not be repeated. *Science has come to stay.*

What has the study of science already done? It has enlarged the domain of human thought and helped us to understand the wonderful universe in which our lot is cast. It has shown us at the same time how all the multitudinous forces of Nature may be harnessed for our use and how some of her most hidden ways may be utilised for the greater happiness and convenience of mankind. Some of the results she accomplished long before the present century dawned, but the century is as remarkable for the development of the old as it is for the creation of the new, and this chiefly by the reflex action of the new on the old in providing mechanical and instrumental aids of undreamt-of power.

Let us first deal with our splendid century in the light of the new knowledge and new helps more especially associated with it.

The gift of science to the opening years of the century was the steam engine then coming into common use. Watt's patent expired in 1800. When one reads how it was that Watt achieved one of the most tremendous revolutions recorded in history, one cannot help feeling that his position as "mathematical instrument maker to the University" (at Glasgow) had everything to do with it; he lived with his friend Black in an atmosphere of research. The steam-engine, so closely are all scientific applications bound together, underlies all our modern progress, for the reason that hand labour, thanks to it, has been replaced by greater powers. Tubal-Cain and the "blacksmiths" who descended the Nile Valley before the pyramids were built, could mould iron, but they could never have made machinery, as we now understand it; and telescopes and telephone wires, and even the instruments used nowadays in wireless telegraphy are made by machinery.

One of the first applications during this century of the new source of power was to apply it to locomotion. This was done by Watt himself and Symmington on the Forth and Clyde Canal, in 1802.

Our present enormous battleships and mail steamers, and also our destroyers going at thirty-five miles an hour, are doubly the result of Watt's work. It is the steam engine which builds them and drives them when built. It may even be that Mr. Parsons, at the end of the century, will prove to us that Watt's method of applying steam to marine locomotion can be improved upon for some uses.

Land locomotion by means of steam followed in 1829, the Rocket and the Stockton and Darlington Railway inaugurating the long series of engines and railways which now make rapid and safe transit possible almost over the whole surface of the civilised world, both speed and economy being secured by James' invention of the tubular boiler.

Certainly in the steam engine and in its application to locomotion by sea and land we have the causes of two most momentous changes in our civilisation; they have been brought about by the application of the study of the phenomena of heat, first in softening metals, next in vapourising liquids.

Electricity comes next with its wonderful record of electric telegraph, electric light, electric traction, telephones and wireless telegraphy, and all since 1836! Of the applications of electricity, after what has happened, he would be a bold man who would venture to predict where they will stop, or that no equally striking developments are yet in store for us. If they come it will be because the future will produce its Faradays or its Kelvins.

The world in general has been less struck with the results of the study of magnetism *per se* than with that of electricity. Still its victories include the study of the magnetic forces at work over all the water surface of the globe, and the power of using a compass in an *iron* ship, without which navigation would be a very different thing from what it is. Nor must we forget the demonstration of some still mysterious bond between the earth and the centre of our system with which the periodicity of sun spots, magnetic storms and auroral and some meteorological conditions of our earth are bound up. Here

certainly we are face to face with one of the sciences of the future.

The saving of the lives of our sailors by storm warnings and the study of the laws of storms is one of the applications of the science of meteorology which the century has brought us, a result undreamt of by him who first "weighed the air." Nor do the benefits of science to our seafaring and sea-going populations end here. Ocean currents as well as air currents have been investigated and charted by hydrographers, who have added to these benefits maps showing depths, so that now the contours of the bottoms of seas and oceans are nearly as well known as those of the land surfaces.

"The anatomy of the earth," as geology has been termed, is also practically a product of the present century, though it may be said that for its beginning we have to look to Arabian writers of the tenth century. The later work has not only enabled us to become familiar with the surface conditions of the earth in past ages, but to construct tables showing the various forms of animal and vegetable life which one after the other have peopled our planet.

More than this, man himself has been proved to have been present on the scene contemporaneously with many now extinct animals, at a time long antecedent to that favoured by Archbishop Usher. This work has been extended by the modern science of Archæology which has demonstrated the existence of settled communities and by no means rude civilisations thousands of years ago, and it is now evident that in "the noblest study of mankind" the geologist and archæologist must work together to dive still further into man's early history.

But there has also been another very practical application of geological study. Geography long ago gave us maps of land surfaces, geology has now based upon them geological maps of priceless value to all interested in the products of the mine. In no direction, perhaps, is the influence of the modern scientific wave better demonstrated than in the fact that in the newest countries such maps are the first care of those in authority, while some of the oldest are still without them: this is little to be wondered at, for, read in the light of science, they give us certain knowledge of the riches lying beneath, and the modern steam-engine does the rest. Hence the enormous development of the Mining Industry in all lands in recent years.

For another enormous industrial advance brought about by quiet research we have to look to Chemistry. The rise, and I am sorry to say the fall in this country, of this industry has been one of the most remarkable things of the century. On this I shall have to say a word presently.

I must not dwell longer on the more modern sciences. Let me turn next to those which have been long cultivated.

It was formerly thought that the study of organic nature could have no possible application; that the study of animals and plants led to classification chiefly, if not exclusively.

In this region of thought we find another revolution as striking, if not more striking, than those already referred to. The genius of Darwin has evolved from this study "the origin of species;" that is the real cause of the introduction of new forms, and has brought us in

presence of the work of evolution in moulding the animal and vegetable kingdoms through the vast geological periods, and, what is more important from the practical point of view, in our own times.

Medicine and astronomy are certainly the most ancient of the sciences, and yet, strange to tell, the advances here have equalled any other to which I have referred.

I am an old man now, but still I distinctly remember how large was the number of faces marked with the small-pox, encountered in an hour's walk in my youth. Such sights, and the deaths and ravages caused by this fell disease, have practically been abolished by vaccination introduced by Jenner in the first half of the century. Pasteur and Lister have made for themselves immortal names since then, and at the end of the century we find ourselves on the track of the causes of most diseases. The germs from which they spring are known, and *preventive* medicine is now a well-understood science. Hydrophobia, diphtheria, consumption and other dire human maladies shew signs of capitulation, while Listerism enables the surgeon to succeed in operations which were formerly never attempted.

Much of this tremendous alleviation of human pain, and the attendant increase in the span of life have depended upon the improvement in the microscope brought about by the study of optics. Strangely enough, the last important progress to which I shall refer comes to a large extent from the same source.

The earliest victories of astronomy were achieved without any instrument. The horizon formed the only point of available reference; then came instruments with-

out the telescope and clock; next these were added. The steam-engine and improvements in the manufacture of glass followed, and permitted the construction of enormous telescopes; finally we have the optical studies, to which I have referred, carried on in strict alliance with chemistry. Celestial objects which the human eye will never see are now studied in a hundred ways by means of photography, and the heavens have been expanded for us a thousand-fold; and chemistry has not stopped here; the substances of which the most distant worlds are composed are now well within our ken.

With hundreds of thousands of firm facts at our disposal, we can now watch the gradual formations of worlds, and study both cause and effect. Hence a new idea of cosmical evolution, and hence also an idea of another evolution which deals with the gradual formation of the chemical substances of which our own earth as well as the distant worlds are built up.

All the world knows of the many applications of the old Astronomy, some of which have been so improved in recent years that a ship at 16 knots speed can determine her position to a mile in any part of the trackless ocean. The applications of the new astronomy are yet to seek, but they will come.

The preceding hasty sketch of the progress of science and the attendant progress in industry during the century will conclusively show that Bacon has been proved to be more than right in his estimate of the material benefits which must follow from a study of pure science; and it is not too much to say that to-day there is no branch of pure science which has not its application, and no application of science which has not helped to enlarge the

boundaries of the branch of pure science on which it is based.

I cannot refrain from quoting what Huxley wrote in this particular connection some years ago :—

"If science has rendered the colossal development of modern industry possible, beyond a doubt industry has done no less for modern physics and chemistry and for a great deal of modern biology. And as captains of industry have, at last, begun to be aware that the condition of success in that warfare, under the forms of peace, which is known as industrial competition, lies in the discipline of the troops and the use of arms of precision, just as much as it does in the warfare which is called war, their demand for that discipline, which is technical education, is reacting upon science in a manner which will, assuredly, stimulate its future growth to an incalculable extent. It has become obvious that the interests of science and of industry are identical; that science cannot make a step forward without, sooner or later, opening up new channels for industry; and, on the other hand, that every advance of industry facilitates those experimental investigations, upon which the growth of science depends."*

Years ago a distinguished man of science said that "applications" were the "froth and scum" of science. Were he alive he would not say so now, for the reason that experience has shown that the most useful applications are often suggested by those whose life is chiefly spent in studying scientific principles; indeed, one of the morals of our recent progress is that the study of the purest science is the best way of increasing those so-called "applications" which have proved to be so useful to mankind, *sooner or later*. There are many instances of researches ideally useless at the time they were made which have ultimately resulted in the most important applications. Faraday's "trifling" with wires and magnets and Newton's examination of sunlight through a prism are cases in point.

* "Method and Results." Essays, T. H. Huxley, page 55.

It is from such considerations as these that the importance of study in all branches of science without regard to immediate applications may be gathered. It is often forgotten that the unstudied is the mine from which, one by one, with study, all applications have been won; the purest science, then, is the one so far least drawn upon. It is, therefore, as history shows us, the one which will prove most fruitful in the future.

What is to be learnt from all this?

An industrial battle between the foremost nations is always going on, and in the struggle for existence in each market the fittest nation will survive. Each nation depends for its life upon its industry. Industry depends upon science. The progress of science depends upon the number of men of science *at work* in each country. This number chiefly depends upon the education afforded in each country. The basis of all scientific work is the power of thinking, observing and experimenting correctly—the best use of mind and eyes and hands. This, then, is the natural basis of the earliest education.

The next moral is this. If a nation wishes to go under in the struggle, the very best plan is to waste the time of the young at the primary school by educating on some other system than that indicated—let us say teaching a trade. Next waste the time of the older students, supposing science is taught to them at all, by a so-called "technical instruction" concerning applications without any practical work at, or research connected with, any one branch of pure science. Next turn men thus prepared into works and factories where they will be able only to slavishly follow their predecessors by using rule of thumb processes. Such a course as this will effectively

prevent any development of the industry concerned; no new processes will be forthcoming, no new methods based on new discovery, and no new products.

If a nation wishes to succeed in the struggle she must see to it that the earliest of the school years shall be spent in providing such a fully co-ordinated education as I have indicated; and the after years, and many of them, utilised in building a knowledge of pure science on this foundation by means of research. Men thus educated, when they find their way into industry, are not forced to be content with the old methods of work if they can see their way to improve them. They do improve them and discover new ones. Next they discover new applications altogether and eventually in this way open up new markets with new commodities.

These are no fancy pictures. We had these two methods in operation fifty years ago. The first in England, the second in Germany, and the result of their working has been that England has lost her chemical industries, as I hinted before. But not in relation to these industries alone has the value of the second method been established by the logic of facts. The final moral I wish to impress upon is that if England suffers Germany or any other nation to surpass her in the arts of peace—that is in the application, of science to the needs of mankind —the fall of the Empire must come sooner or later.

Now that science is the great factor in the history of the world, what is done during peace and not during war will decide the fate of nations.

EDUCATION IN THE NEW CENTURY.

(1901.)

Science is cosmopolitan. Electricity abolishes time and envelops both hemispheres with a new idea as soon as it has emerged from the brain of the Thinker. Mechanics, by its space-annihilating power, has reduced the surface of the planet to such an extent that the human race now possesses the advantage of dwelling, as it were, on a tiny satellite. Both these agencies, then, combine to facilitate a rapid exchange of new ideas and commodities, as well as of those who are interested in them in whatever capacity.

These considerations indicate some of the most momentous changes which have occurred in the world's history since the last century dawned.

How have they been brought about? M. Maurice Lévy, in one of those allocutions—always so admirable in thought and style—pronounced by the President of the French Academy of Sciences at the annual public meeting held each December, has answered this question for us :—

"Let us never forget that if applied mechanics has arrived to-day at such marvellous results, if we can now calculate beforehand the parts of the most complex machines, it is because long ago the shepherds of Chaldea and Judea observed the stars ; because Hipparchus combined their observations with his own and handed them down to us ; because

Tycho Brahe made better ones; because two thousand years ago a great geometer, Appolonius of Perga, wrote a treatise on conic sections, regarded for many centuries as useless; because the genius of Kepler, utilising this admirable work and the observations of Tycho Brahe, gave us those sublime laws which themselves have been considered useless by the utilitarians; and, finally, because Newton discovered the law of universal gravitation."

From this discovery of Newton, M. Lévy points out, first came the study of celestial mechanics, from which was derived later general mechanics, from which again, later still, industrial mechanics has taken its origin, and is now applied every day. He adds:—

"It is well to impress the fact that Industrial Mechanics has come down from heaven, upon the utilitarians; upon those who appreciate science only so far as it can be immediately profitable to them; who are always complaining that too much is taught at school; and who regard as superfluous everything they cannot find in a formulary, manual or aid to memory."

All our progress, then, if we accept the view to which M. Maurice Lévy has given expression, has come from the study of what was useless at the time it was studied. There is no doubt that this view is correct, and that further developments, probably as momentous as those to which we have already referred, will in the future come to us from the same source.

To study the useless, therefore, is as important as to apply the useful, from a cosmopolitan point of view; and all wise governments and institutions should use their most strenuous efforts to aid the first endeavour; the second can very well take care of itself.

There can be no question that the progress of science and of the applications of science to industry will go on in a geometrical ratio, and that eventually every country will benefit by this advance; but if we quit the cosmo-

politan point of view and endeavour to form an idea of the results of this advance on any country in particular, another set of considerations comes in.

Our Empire, as it exists at present, and our great national wealth, are the results of the sea-training and prowess of her sons and of the stores of natural wealth in the shape of coal and iron which the first appliers of mechanics found to their hand. The output and first user of coal and iron depended upon the applications of mechanics, and the first user of all these combined enabled us to flood the markets of the world, and for years Britain was the Tubal Cain among the nations. Not only had we a monopoly of export, but so high an authority as Sir Andrew Noble acknowledges that fifty years ago British machinery was immeasurably superior to any other. But even this statement does not exhaust all our then advantages. Because we were the great producers we became the great carriers of the world, when Germany did not exist as a united nation, France was mainly agricultural, and the United States were engaged in developing their enormous and almost unpopulated territories.

But what has happened since? As we have said, science is cosmopolitan, and the levelling effect of this has been that the *material* advantages we possessed in the first instance have disappeared. Other countries, chiefly those we have named, have now their coal and iron and applications of science as well as ourselves.

First among these applications at the beginning of the last century came steam locomotion, and from the work done on the Forth and Clyde Canal have sprung all the navies and railways of the world.

For traction purposes steam is now giving way to electricity; but how different is the *rôle* that Britain is playing at the beginning of the new century compared with that she filled at the beginning of the old one. We import instead of exporting. The chief London electric railway is American, American coal is producing gas to light the streets of the Metropolis, American cars are now found on our English trains which on some lines are drawn by American locomotives. British applications to facilitate locomotion, therefore, have ceased to be paramount, and at the same time we no longer occupy the proud position of being the only nation of shopkeepers.

Were this all, it would be abundantly clear that our old supremacy must cease, and from no fault of our own, as it is but a direct consequence of the general progress of science, which includes the facilitating of inter-communications. But, unfortunately, it is not all.

At a time when our ancient universities occupied no higher level than that, according to Matthew Arnold, of Secondary Schools, and when there was little attempt at educating the large majority of the population, Prussia, which, with the rest of the German States, had been the first to insist upon the importance of the education of the people, had occupied herself, crushed though she was after Jena, with the founding of universities and with the highest education; while live seats of learning in great numbers were being founded in the United States. The beginning of the new century, then, finds us in a position which every day differs more and more from that occupied by us in the old one, for not only are our natural resources

relatively reduced in value, but our intellectual resources are not sufficiently superior to those of other nations to enable us to retain our old position by force of brains.

As an early instance of the result of this state of things we may refer to Mr. Perkin's account, in 1885,* of the migration of the coal-tar industry to Germany. In later years ample proof has been adduced that in many directions the present British intellectual equipment is not only not superior, but actually inferior to that of other countries, and none too soon the matter is engaging attention in the daily press. Recently *The Times*, *Daily Mail* and *Pall Mall Gazette* have called special attention to the reasons which may be assigned for this new and alarming state of things; a writer in the *Fortnightly* has gone so far as to ask, "Will England last the Century?" while Sir Henry Roscoe has expressed his opinions in a letter to *The Times* as follows:—

"There can be no manner of doubt that a crisis in our national well-being has already been reached. The news brought to us from all quarters proves that our industrial and commercial prosperity is being rapidly undermined. The cry that we are being outbid on all sides by Germany and America is no new one, but it becomes louder and louder every day, and now it is admitted by all those best qualified to judge that, unless some drastic steps are taken to strengthen our educational position in the direction long ago taken up by our competitors, we stand to lose, not merely our industrial supremacy, but the bulk of our foreign trade. . . . The only policy at this time is to strain every nerve to place the country educationally on a level with its neighbours. No effort, no expenditure, is too great to secure this result, and unless our leaders, both in statecraft and in industry, are quickly aroused to the critical condition of our national affairs in this respect, and determine at once to set our house in order, our children and grandchildren may see England sink to the level of a third-rate Power; for upon education, the basis of industry and commerce, the greatness of our country depends."

* *Nature*, vol xxxii., p. 343.

We must confess that when we come to consider the panaceas suggested by these writers we find much more vagueness than might be expected, and some suggestions which are entirely beside the mark.

Thus we are told that now our Colonies are being more closely united to us, we may rest and be thankful; that American industry depends for its success upon the extreme youth of those who are at the head of affairs. Education is referred to as if there were no differences in the methods employed, and finally a newly-developed sloth is suggested as the origin of the apparent decadence of the most athletic nation in the world.

The question arises, Is there no scientific method open to us to get at the real origin of the causes which have produced the present anxiety?

M. Maurice Lévy, in his allocation, did England the honour to point out how large a share Newton had in founding the industries on which our commercial greatness in the last century was based. It seems to us to be our duty, at the beginning of the new century, to suggest that at this critical time it would be criminal to neglect the labours of another great Englishman—Darwin—which may be appealed to to help us to see what has gone wrong and to forecast what the future has in store for us if we apply the suggested remedies or if we neglect them. In this we possess an advantage over our forerunners; Darwin has shown the working of an inexorable law which applies exactly to the conditions under which we find ourselves.

The enormous and unprecedented progress in science during the last century has brought about a perfectly new state of things, in which the "struggle for existence"

which Darwin studied in relation to organic forms is now seen, for the first time, to apply to organised communities, not when at war with each other, but when engaged in peaceful commercial strife. It is a struggle in which the fittest to survive is no longer indicated by his valour and muscle and powers of endurance, but by those qualities in which the most successful differs most from the rest. We must accept the conclusion that, with material outfits now much more equally distributed for this struggle for existence, if Britain be at a disadvantage in relation to any other nation with regard to these qualities, she must go under if such a condition of things be allowed to go on. If this appeal to a natural law leads to such a dire conclusion, it is the duty of every Briton, from the highest to the lowest, to see to it that some efficient remedy be applied without delay.

It follows from what has already been stated that we need not look for these national differences among natural products for the reason that, day by day, such differences are being levelled by the present ease and rapidity of intercommunication.

We do not think that the differences will be found in any very great degree in our primary and technical instruction as it is going on to-day.

If we regard our primary, secondary and higher education, it must be acknowledged that great improvements have been carried out during the last quarter of a century. The establishment of new universities, adapted to the present conditions of civilisation, in several great centres, and the promise of more, has clearly shown that, in the opinion of our most important mercantile communities, strong measures are necessary, and

that they are prepared to make great pecuniary sacrifices to carry them out. Still, the facts show that what has already been done is not sufficient, and that we must do more in these directions; but the present difference in these respects is not entirely sufficient to account for the present condition of things.

Continuing our process of exclusion, we finally arrive at the possibility that the present superiority of our competitors depends as much upon Liebig's introduction of practical scientific work and research into the general higher education as did our former supremacy upon Watt's introduction of the steam engine. Voltaire said, "On étudie les livres en attendant qu'on étudie les hommes." The proper study of science gives us a third term, the study of things and laws in action; a study in which the eye and hand and brain must work together to produce the scientific spirit, or properly organised common sense.

The scientific spirit existed among our European competitors much more generally than it did with us long before Liebig, and it was utilised over a far wider field of knowledge; but from Liebig's time it has existed among them as the dominant factor in Industry and Commerce, and the closer union between Science and Industry in other countries is, we believe, the true origin of the present difference between them and our own.

Here, we tried to start chemical industries practically without chemists, as Mr. Perkin has told us. In Germany they are now carried on by scores, in one case more than a hundred, of the best trained chemists the country can produce, in research laboratories attached to all the great works. At this moment German artificial

indigo threatens to replace the natural product in all the markets of the world as a result of these scientific industrial methods. So soon as science was acknowledged to be the most important commercial factor, the Reichsanstalt was established by the Government at a cost of 200,000*l.*, and a yearly expenditure of 15,000*l.* to weld science and industry more closely together. An American professor thus summarises the results :—

"The results have already justified, in a remarkable manner, all the expenditure of labour and money. The renown in exact scientific measurements formerly possessed by France and England has now largely been transferred to Germany. Formerly scientific workers in the United States looked to England for exact standards, especially in the department of electricity; now they go to Germany."

And again :—

"Germany is rapidly moving toward industrial supremacy in Europe. One of the most potent factors in this notable advance is the perfected alliance between science and commerce existing in Germany. Science has come to be regarded there as a commercial factor. If England is losing her supremacy in manufactures and in commerce, as many claim, it is because of English conservatism, and the failure to utilise to the fullest extent the lessons taught by science."

Britain, of course, is the country in which such an institution ought to have been established more than half a century ago. We are now compelled to imitate it; but the new institution which, before long, may be instituted is on such a microscopic scale that its utility in the present struggle is more than doubtful.

The next conclusion the appeal to the law provides us with is that the improved scientific instruction of those engaged in industry is not the only line along which our defences must be strengthened. The scientific spirit must be applied as generally in England as elsewhere.

The increasing complexity of industrial and national

life requires a closer adjustment of means to ends, and this can only be attained by those who have had education on a scientific basis, and have therefore acquired the scientific habit. In this way only can we lift the whole standard of our national life to a higher plane, and weld the various national activities together.

We must have a profound change of front on the part of the Ministry and the *personnel* of the Government departments, only very few of whom have had any scientific education, and who at present regard all scientific questions with apathy, on the ground, perhaps, that in their opinion the Nation has no direct concern with them. This feeling may be strengthened by the fact that at present, while the laws of the realm are well looked after by the most highly paid servants of the State, the laws of Nature are left without anybody to form a court of appeal in difficult questions. It is true that to fill this gap our men of science are always ready, when called upon, to spend time and energy in affording, gratis, to the Government advice on any questions which may be submitted to them; but because this advice costs nothing its value is, perhaps, estimated by what it costs.

Our rulers must recognise that, in virtue of the law to which reference has been made, it will not do to confine their energies and the national expenditure, so largely as they do now, to matters relating only to the Navy and Army, the functions of which are to protect our world-wide Empire at present well worth conquering, our industries and our argosies on every sea—products, all of them, of our old scientific and therefore commercial supremacy.

Several obvious corollaries from the law in question

indicate very clearly the proper course to pursue—in our own case to retain our position, in the case of our competitors to improve their own in relation to us, and therefore at our expense. There are many signs that our competitors, at all events, have faced this problem and are working on true scientific lines; of this the heavy subsidy of the German mercantile marine may be given as one instance out of many, and here, indeed, we are brought face to face with the consideration that the scientific outlook should really be as important to those in charge of the nation's future well-being as that concerned with international politics.

If the other nations, by their scientific activity, increase their commerce and therefore their commercial fleets, their national fleets must be increased also. Our present policy with regard to our fleet is well established, so that we are committed to its continuous and well-defined increase, while it seems to be the duty of no Government Department to look after the scientific advances which are the only bases of the commerce which is to provide for our constantly increasing expenditure.

These considerations are only typical of others which are well worth considering at the present juncture by men possessing the scientific spirit. What is the best way of utilising the combined forces of the Empire, in times of peace, under the present conditions? It is clear that no merely sentimental bonds will be sufficient. We may add that peaceful conflicts between industrial peoples are not alone in question.

With regard to preparation for war, history has already taught us much. Of two competitors, if one be fully armed both for offence and defence, and the other is

not, there is no doubt as to what will happen. That nation will be the best off which utilises the greatest number of its citizens both for war and peace. A large standing army in times of peace is a clear indication that the scientific spirit has not been sufficiently applied to the problem, and it is to be hoped that now the future of the nation is being discussed, the attempts to put our house in order will be made on scientific lines.

THE ORGANISATION OF KNOWLEDGE.

(1902.)

The *London Gazette* announces that a petition for incorporation has been presented to His Majesty on behalf of a new body, "The British Academy for the Promotion of Historical, Philosophical and Philological Studies." An explanation has been given that the object of this institution is to do for the various departments of "literary science" what the Royal Society has achieved for "natural science." The causes which have led up to this proposal may be stated as follows. At a meeting of the representatives of the chief European and American Academies held at Wiesbaden in October 1899, an International Association of the principal Scientific and Literary Academies of the world was decided upon. Most of the Academies represented are divided into two sections, a section of natural science and a section of historico-philosophical science. And on this ground the scheme provided for the division of the new association into two sections, "scientific" and "literary," the word "literary" being used only as a short title to embrace the sciences of language, history, philosophy, archæology and other allied subjects the study of which is based on scientific methods. At the conference the representatives of the Royal Society, not feeling themselves competent to represent the United Kingdom in

the philosophico-historical section, were unofficially requested to take such steps as might be possible to fill this gap in the future.

The next steps taken may be gathered from the Report of the Royal Society Council presented to the Society on November 30, 1901.

The secretaries, apparently in fulfilment of their undertaking at Wiesbaden, wrote on the subject to the president of the Society of Antiquaries, Viscount Dillon, on November 21, 1899. A meeting was called at which, among others, several fellows of the Royal Society and of the Society of Antiquaries were present. The conclusion arrived at was that the idea of an academy to represent the philosophico-historical subjects formed by the simple federation of existing societies was not one which appeared to meet the views of those present.

At the same time the late Professor Sidgwick drew up a plan which was approved by several of those attending the meeting and "of which the resolution passed at that meeting might be considered a part." This plan was that the Royal Society might enlarge its scope and include a section corresponding to the "philosophico-historical" and "philological" division of the German Royal Academies and Societies.

The next step taken was the reference of the matter to a special committee of the Royal Society.

This Committee point out that four possible ways of dealing with the matter were submitted to them:—

"(1) The creation of an organisation independent of the Royal Society, though possibly in some way connected with it, in which case they might both form parts of some larger body, as, for instance, the French Academies, form parts of the Institute of France.

"(2) The creation of two 'Academies' within the Royal Society,

one of Mathematics and Natural Sciences, the other of Philosophy-History, each Academy having its own Council, Secretaries and President, and the President of each being in turn President of the whole Society.

"(3) The creation of two or of three 'Sections' of the Royal Society, either A and B, corresponding to the Academies just named; or, A, Mathematical and Physical Sciences, B, Biological Sciences and C, Philosophico-Historical Sciences.

"(4) The election of some twenty-five to fifty Fellows representing the Philosophico-Historical subjects, to serve as a nucleus, and the creation of three or four committees, similar to those already existing, viz., one for Ethnography and Archæology, one for Philology, one for Statistics and Political Economy and one for Psychology, the Officers and Council remaining, so far as statute and enactment are concerned, precisely as they are at present."

After these schemes had been formulated they were discussed at an interview with a number of representatives of the philosophico-historical sciences. Concerning this interview we read:—

"They all expressed themselves in favour of any effort for the corporate representation of those sciences being associated in some way or other with the Royal Society. They seemed unanimous in feeling the great desirability of the organisation and official representation of the Philosophico-Historical subjects, both on the ground of the general encouragement of their pursuit, and also, and more especially, as a means of developing the more scientific methods of treating those subjects.

"The general opinion of these gentlemen upon the practical courses discussed in the Report seemed to be in favour of the plan numbered (3) in the Report, but, recognising the practical difficulties in the way of carrying out any such scheme immediately, they were generally in favour of an effort being made on the lines laid down in plan numbered (4) as a beginning, in the belief that should its adoption lead, as they believe it would, to greater activity in this country in the studies in question, there might ultimately develop out of it some more formal organisation, such as is contemplated in the other plans submitted."

It is frankly stated that the Committee were much impressed by the concurrence of opinion among the

gentlemen whom they consulted and by the high value they set on the inclusion within the scope of the Royal Society's action of the subjects they represented.

After the Report of this Committee was sent in to the Council, a special meeting of the Society was called for May 9, 1901. Unfortunately there is no record of what took place at it, but at the Council meeting in June the following resolution was passed:—"That the Council, while sympathising with the desire to secure corporate organisation for the exact literary studies considered in the Report, is of opinion that it is undesirable that the Royal Society should itself initiate the establishment of a British Academy."

The Times now tells us that on June 28, 1901, a month after this resolution was arrived at, those interested in the proper representation of the "literary" subjects met at the British Museum and

"after long and careful deliberation resolved to promote the establishment of a British Academy of Historical, Philosophical and Philological Studies on conditions which would satisfy the requirements of the International Association of Academies. It was further decided that the Academy should petition for incorporation by Royal Charter, and that the nomination of the first Fellows under the proposed charter should be forthwith taken in hand. Before the close of last year, on December 17, the British Academy held its first meeting at the British Museum and petitioned His Majesty for incorporation by Charter."

According to the draft Charter the petitioners will be the first Fellows of the Academy and the President and Council will be elected by the Fellows from amongst their own number. New Fellows will be elected at a general meeting of the Fellows.

The announcement in the *London Gazette* states that His Majesty has referred the petition to a committee of

the Lords of the Council. Notice is further given that all petitions for or against such grant should be sent to the Privy Council Office on or before February 14 next.

A Letter to "The Times." *

To the Editor of *The Times.*

SIR,—All students of natural knowledge in this country should agree as to the importance of the step recently taken to organise certain branches of it, concerning which you have given your readers much information. There are, however, some points connected with the movement on which you have not yet touched. Will you permit me to refer to them and the conclusion to which they lead?

The petition to His Majesty for a Charter to embrace the organisation of historical, philosophical and philological sciences was rendered necessary by the action of the council of the Royal Society, who declined to "initiate the establishment of a British Academy" dealing with these subjects. But, in the first instance, the desire of those interested in the movement was that the Royal Society might include in itself a section corresponding to the philosophico-historical and philological sections of the Continental academies; it was not a question of establishing a British Academy.

To consider the matter in this form a committee of the Royal Society was appointed and its Report has recently been published. In this Report we have the following reference to the subjects dealt with by the historical and philological sections of foreign academies:—

These subjects have, in England, hitherto remained unorganised—that is to say, the workers in each one of them have been brought

* January 29, 1902.

into little or no relation with the workers in each of the others. Societies have been founded for the promotion of some of them, but these societies are not linked together by the membership of their leading members in one body of recognised authority and influence, such as the Royal Society provides for the investigators of various branches of mathematical, observational and experimental science.

The advantages which the gathering into one body of the men most eminent in the subjects above specified has secured in Germany, France, Italy, and Belgium do not exist here, and the absence of any effort to secure them has often excited the surprise of learned men in those countries. Neither is there in England any series of Transactions similar to those of the leading academies of Continental Europe, in which records of the most fruitful inquiries in those subjects, or even systematised references to such inquiries, may be found.

We are next told that the following reasons, among others, have been suggested by eminent men as making it desirable that the Royal Society should take action in the matter :—

Assuming the organisation of the above subjects to be called for in the general interest of the intellectual progress of the country, the Royal Society can promote their organisation more effectively than could be done by the persons who are occupied in the study of them, because these persons have no sort of combined corporate existence, and no voluntary group of them would appear to have a proper *locus standi* for appealing to the public or approaching the Government in order to attain the object sought.

It has been urged on general grounds that the inclusion by the Royal Society of a section corresponding to the philosophico-historical and philological divisions of the German academies would strengthen the society by broadening the range of its scientific activity and increasing its influence; and would be to its advantage inasmuch as such a course would anticipate and thereby make needless the formation of an association which, by gathering the subjects within its scope, might to that extent be in rivalry with the Royal Society and tend to narrow the legitimate range of its activity.

And next comes the most important part of the Report, indicating that in the past, and by the three Charters granted by His Majesty Charles II., the subjects under

discussion were, and should be, held to refer to "natural knowledge," and, therefore, should be dealt with by the Royal Society :—

The society exists for the promotion of natural knowledge. The interpretation of the term "natural knowledge," according to the present practice of the Royal Society, assigns to it a range from mathematics to the various biological sciences, and thus secures the inclusion of the scientific study of man in his biological relations. . . .

It is evident that the charters have never been interpreted as confining the "studies" of the society to "further promoting by the authority of experiments the science of natural things and of useful arts" in the strict modern meaning of those words. Indeed, the second charter in terms empowers the society to hold meetings "for the examination and investigation of experiments and of natural things," and both charters authorise it to enjoy "mutual intelligence and affairs with all and all manner of foreigners" . . . "in matters or things philosophical, mathematical or mechanical." The provisions of the first statutes that the business of the society at its meetings shall be "to order, take account, consider and discourse of philosophical experiments and observations; to read, hear and discourse upon letters, reports, and other papers containing philosophical matters, and also to view and discourse upon rarities of nature and art;" and the long and uninterrupted usage to receive papers on observational sciences, such as geology, or on pure mathematics, certainly does establish a *contemporanea expositio* which must be taken into account as *optimus interpres* and *fortissima in lege.*

Even had papers upon philological, psychological or other subjects been entirely absent, no stress could be laid upon that fact, if in the opinion of the society those subjects have, under modern methods of treatment, become observational sciences, and as fully parts of "natural knowledge" as those subjects which were recognised as such at the epoch of the foundation of the society.

It would clearly be *ultra vires* for the society to resolve to receive a new class of papers, incapable of being regarded either in subject-matter or in scientific treatment as in the same category as those which have hitherto been received. But it would not be unlawful for the society to determine to receive papers on subjects not hitherto regarded as properly within its scope if it came deliberately to the conclusion that, in view of the scientific method in which they were now being treated, those subjects ought not to be excluded from its study.

The committee was not content with expressing its own view on this important matter; it privately consulted two high legal authorities, whose opinion led the committee to believe, in confirmation of the views above stated, that the inclusion within the scope of the society of such subjects as have been referred to, if treated by scientific methods, is "within the powers of the society."

Two extracts from the first Charter granted by Charles II. alone seem to establish this conclusion. The Charter begins as follows (I give the English translation as it runs in the "Record of the Royal Society, 1879"):—

> Charles II., by the grace of God King of England, Scotland, France and Ireland, Defender of the Faith, etc., to all to whom these present Letters shall come, greeting.
>
> We have long and fully resolved with Ourself to extend not only the boundaries of the Empire, but also the very arts and sciences. Therefore we look with favour upon all forms of learning, but with particular grace we encourage philosophical studies, especially those which by actual experiment attempt either to shape out a new philosophy or to perfect the old. In order, therefore, that such studies, which have not hitherto been sufficiently brilliant in any part of the world, may shine conspicuously amongst our people, and that at length the whole world of letters may always recognise us not only as the Defender of the Faith, but also as the universal lover and patron of every kind of truth: Know ye, etc.

Of the "Fellows" we read later on:—

> The more eminently they are distinguished for the study of every kind of learning and good letters, the more ardently they desire to promote the honour, studies, and advantage of this Society . . . the more we wish them to be especially deemed fitting and worthy of being admitted into the number of the Fellows of the same Society.

"Every kind of learning and good letters" seems to me pretty general, and it does not seem improper to take the words "philosophical studies," in connection with Bacon's definition of philosophy, as dealing with a three-

fold division, of matters divine (supernatural), natural and human, which also, perhaps, explains the subsequent insistence upon natural, as opposed to supernatural knowledge.

But, without labouring this point further, I suggest that subjects the study of which by scientific methods increase the sum of natural knowledge must all stand on the same footing. I use the word "scientific" in its widest, which I believe to be the truest, sense, as including all additions to natural knowledge got by investigation. Human history and development are as important to mankind as the history and development of fishes. The Royal Society now practically neglects the one and encourages the other.

It is possible, then, to say the least, that the present general action of the society, and I say general, because the action changes from time to time, is really not in accordance with its charters; it certainly is not with its first practice. The charters make the society the head centre of the intellect of the kingdom engaged in making new natural knowledge, and therefore until these charters of King Charles II. are abrogated or revised there is no place logically for a new charter by King Edward VII. giving power to a new body to deal with the subjects the duty of the organisation and encouragement of which was previously committed to the Royal Society.

There can be no question that the gradual departure of the action of the Royal Society from the course laid down in the charters, and actually followed for a time, has been the gradual expansion and increased importance of experimental and observational methods of work, which of themselves are sufficient to employ the existing administra-

tive machinery. But if the whole work cannot be done inside the society as it exists at present, the question arises, "Cannot some be organised side by side with it?" Here, again, there may be difficulties; but, as the committee wisely say with regard to the first proposal:—

> We are far from intending to express an opinion that any difficulties of detail ought to prevent the important issues involved from being fully considered in their largest bearings, having regard to the great benefits which might be expected to result to the progress of the philosophico-historical studies, and possibly to the Royal Society itself, from the inclusion of those studies within the scope of the Society's action.

It is right that I should say that the Royal Society Council, in the resolution from which I have already quoted, expresses sympathy with the desire to secure a proper representation of the subjects now in question, and did not refuse to include them within itself, although its action may give colour to the belief in such an effect.

At present the Royal Society is the unique recognised centre of the general scientific activity in this country.

Will it be conducive to the interests of science, or even of the Royal Society itself, that in future there should be two entirely separate centres?

But will not this state of things be brought about if, without any general consideration, a charter is at once granted to the new body?

The important thing to secure is that the two bodies dealing with the two great groups of scientific subjects shall form part of one organisation—some enlarged Royal Society. What the *nexus* shall be is a matter of such subordinate importance that I do not propose now to refer to it further.

May not this present difficulty, Sir, be really a blessing in disguise? Does it not merely emphasise the activity

of the scientific spirit and the employment of the scientific method in new regions, and suggest that the time has arrived, at the beginning of a new century and a new reign, for doing for the science of to-day what Charles II. did for the science of the seventeenth century—that is, organising and co-ordinating it on a broad basis?

It is clear that the question so wisely referred by His Majesty Edward VII. to the Privy Council is no light one, for the acts of a previous King of England and the future development of British science are involved. The present confusion is great and will become greater if a new charter is granted without a comparison and possible revision of the existing ones; and, short of an inquiry, by a Royal Commission or by some other means, to consider the question, it is difficult to see how the proper organisation of natural knowledge in the future can be secured.

It is fortunate that there is ample time for this important matter to be considered carefully in all its bearings, for not till 1904 can any British representation of the philosophico-historical subjects be considered by the International Association of Academies.

May I finally be permitted to say, Sir, how entirely I agree with the remarks in the leading article in *The Times* of the 16th inst. concerning the importance of organising literature as well as science? Science has undoubtedly gained by the charters of Charles II., and on this ground alone it may be urged that literature will be a gainer if it also be similarly organised. Certainly the most impressive sight I saw in Paris last year, when attending the first meeting of the International Association of Academies as a Royal Society delegate, was the reception

of a new literary member of the Académie Française. The combination of troops representing the Government and members of other academies representing the Institute of France formed a picture which is not easily forgotten; it was one also to set one thinking.

I am, Sir, your obedient servant,

NORMAN LOCKYER.

A Second Letter to "The Times." *

To the Editor of *The Times*.

SIR,—In the references which have been recently made to the early history of the Royal Society, the charters of King Charles II. have frequently been remarked upon, and also the subject-matter of the communications published by the *Philosophical Transactions* from time to time. It has been conceded by many who have given attention to the matter that the charters of King Charles II. intended that the then newly-founded Society should take cognisance, not only of observational and experimental science, but also of those philosophical, historical and philological subjects for which, on the ground that they lack representation to-day, King Edward VII. has been petitioned to grant a charter enabling some new body to look after their interests. It has also been conceded that the early practice of the Royal Society was in accordance with the suggested intention referred to above, so far as the communications made to it enable us to form a judgment.

In a previous letter on this subject, which you were good enough to insert in *The Times* of January 29, I

* March 20, 1902.

pointed out that a committee specially appointed by the Council of the Royal Society to consider the matter had reported, after consultation with high legal authorities, that the inclusion of the subjects within the scope of the Royal Society, for the general organisation of which it is now proposed to found a new Academy, is within the powers conferred on it by the charters of that Society. I venture to give two extracts from the first charter granted by King Charles II. which alone seem to establish this conclusion. If you will permit me, I will reproduce them here :—

> Charles II., by the grace of God, King of England, Scotland, France and Ireland, Defender of the Faith, etc., to all to whom these present Letters shall come, greeting.
>
> We have long and fully resolved with Ourself to extend not only the boundaries of the Empire, but also the very arts and sciences. Therefore we look with favour upon all forms of learning, but with particular grace we encourage philosophical studies, especially those which by actual experiment attempt either to shape out a new philosophy or to perfect the old. In order, therefore, that such studies, which have not hitherto been sufficiently brilliant in any part of the world, may shine conspicuously amongst our people, and that at length the whole world of letters may always recognise us not only as the Defender of the Faith, but also as the universal lover and patron of every kind of truth: Know ye, etc.

Of the "Fellows" it is written :—

> The more eminently they are distinguished for the study of every kind of learning and good letters, the more ardently they desire to promote the honour, studies and advantage of this society . . the more we wish them to be especially deemed fitting and worthy of being admitted into the number of the Fellows of the same Society.

Of course it would have been very much more satisfactory if the committee, instead of enunciating pious and legal opinions as to what the charters enabled the Society to do, as abstractedly as if the Society had never

existed, had, seeing that action under the charters had been going on for nearly two centuries and a half, told us what the Society had really done year after year in the matter of choosing men for election into the Society. In this way sure proof could be obtained of the general opinion of what the charters empowered and enjoined the Society to do, not only at the time they were conferred, but at subsequent dates. This course, which obviously is the only satisfactory way of arriving at a conclusion on the questions at issue, was, however, not open to the committee; because a complete list of the officers, Fellows and foreign members elected in each year from the foundation of the Society was not generally available.

This gap in our knowledge of the actual life of the Society has recently been filled, and we can now learn the kind of work for which the Society considered itself responsible by the men it elected to do it in its early days, and especially by those who were elected to fill the various offices. It will be obvious that a complete inquiry of this nature is a matter involving considerable time and labour; but in the present state of the question raised by the proposition for a new British Academy it is of such high importance to know the facts that I have not hesitated to try to get at them, however imperfectly; my inquiry being limited as much as possible. This has been done by passing over all doubtful cases and considering chiefly the first century of the life of the Society, that is from 1663.

The general result of this limited inquiry may be stated as follows:—

To begin with the presidents. Some were appointed

on account of their rank, others on account of their contributions to observational or experimental science, among them Wren, Newton, the Earl of Macclesfield and others. But besides these we have Sir John Hoskins, "a most learned virtuoso as well as a lawyer," according to Evelyn; Samuel Pepys, of diary fame; Martin Folkes, an antiquarian "under whom the meetings were more literary than scientific;" Sir James Burrow, an antiquarian, also a lawyer; and James West, another antiquarian and collector of coins and given to "black letter lore." If we pass the first century, we find Sir John Pringle, a learned physician and professor of metaphysics and moral philosophy, elected in 1772, and Davies Gilbert in 1827, who, although addicted to science, was chiefly an antiquarian and historian.

Among the treasurers we find Abraham Hill, one of the first appointed, given as much to moral as to natural philosophy; Roger Gale, an archæologist and numismatist; and, again passing the first century, William Marsden (1802), an Oriental scholar, and Samuel Lysons (1810), an antiquarian and an artist.

We next come to the secretaries. The most remarkable thing about these officers is that between 1663 and 1765, of the twenty-nine elected no less than sixteen were doctors of divinity, medicine or law; and, so far as the inquiry has gone, the "Dictionary of National Biography" shows that they were not merely professional men, but scholars first and writers afterwards. The secretary elected in 1776 was Joseph Planta, the librarian of the British Museum; while in 1812 Humphry Davy was followed by Taylor Combe, an archæologist and numismatist.

The office of foreign secretary was created in 1723. Of the eight appointed down to 1772, four were doctors of medicine, and they were selected possibly for the same reason as their colleagues among the secretaries. Maty, who was elected in 1772, was the assistant librarian in the British Museum.

The enormously wide area of knowledge from which the officers of the Society were drawn during the first century is in sharp antithesis to the narrow ground of award of the Copley medal, which was first conferred in 1731. The grant of this medal is limited to the author of the most important discovery or contribution to science by experiment or otherwise; and the greater the divergence between the officers' and Copley medallists' lists, the less, naturally, was the limitation of the Fellowship to those interested alone in experiment or observation.

We next come to the Fellows of the Society. The following lists are based upon a rapid reconnaissance of those who occur early in the alphabetical order, using Hole's "Brief Biographical Dictionary" as a means of determining their identity. The names of many Fellows are absent from Hole, and there are some incertitudes, besides which Hole's definitions are very terse. The lists, however, are given for what they are worth; and there can be little doubt that they will soon be replaced by complete and authoritative lists officially complied. It is important that the Lords of the Privy Council should possess such documents to assist them in the important inquiry with which they are charged; and we may hope that this eagerness to possess is only equalled by the anxiety of the Royal Society to

provide them if their compilation be in the interests of truth :—

Archaeologists and Antiquarians.

Ames, Josh	1743
Amyot, Thos.	1824
Ashmole, Elias	1663
Astle, T.	1766
Ayloffe, J.	1731
Baker, G.	1762
Brander, G.	1754
Bridges, J.	1708
Churchill, Winston	1664
Gale, R.	1718
Gale, T.	1677

Writers.

Askew, Ant.	1749
Barrington, Daines	1767
Bathurst, Ralph	1663
Becket, Wm.	1718
Bentley, R.	1695
Birkenhead, J.	1663
Bowlden, T.	1781
Brocklesby, R	1746
Brown, R.	1811
Bruce, J.	1791
Burnet, T.	1748
Burney, C. (Music)	1773
Cadogan, W.	1752
Chandler, J.	1734
Edgeworth, R. L.	1781
Egerton, F. H.	1781
Farmer, R.	1791
Green, T.	1798

Historians.

Abel, Clarke	1819
Barnes, Joshua	1710
Bates, G.	1663
Beaufort, Louis de	1746

Bernard, C.	1696
Birch, T.	1734
Clarke, J. G.	1792
Coxe, W.	1782
Duclos, C.	1764
Edwards, B.	1794
Ellis, G. A.	1816
Gillies, J.	1789

Philologists.

Colebrooke, H. T.	1816
Dickenson, E.	1677

Poets.

Akenside, Mark	1753
Browne, J. H.	1749
Byron, Lord	1816
Denham	1663
Dryden, J.	1663
Ellis, G.	1797

Travellers.

Bruce, James	1776
Brydone, P.	1773
Carteret, P.	1664
Chardin, J.	1682

Lawyers.

Adair, James	1788
Aland, J. F.	1711
Arden, R. P.	1788
Dalrymple, J.	1796

Although the matter has not as yet been inquired into, there is already ample evidence that the foreign members were selected with the same catholicity as the ordinary Fellows. Thus Sorbière, an eminent French *littérateur*, was elected in 1663 (the first year); the Italian historian Gregorio Leti was elected in 1681; and the French histora Michael Le Vassor in 1701.

It does not seem possible that any unprejudiced mind, after a perusal of the above statements, limited though they are to a point of time, and, in the case of the Fellows, to a few letters of the alphabet, and inaccurate as they may well be here and there, can deny that the reconnaissance affords valuable evidence that the action of the Royal Society for the first century after it had received its charters was as broad as the charters themselves. The Society tried to do, and succeeded in doing, the duty which the charters imposed upon it.

We learn from the above statements that for the period over which my hasty inquiry has gone, Britain possessed a general organisation of learning as complete, though not so detailed, as that of the Institute of France or any other foreign academy to-day. King Charles II. had, in fact, in his charters, and the Royal Society had, in fact, in its action upon them, anticipated the work of Napoleon by very nearly a century and a half; the portals of the Royal Society and of the Institute of France were equally wide, and wide enough to admit the most illustrious men produced in each country.

If I have erred in any way in reading the facts or in drawing conclusions from them, I sincerely trust that someone with more leisure and knowledge than myself will discover where I have gone wrong and at once put the matter right. I am the more anxious that this should be done because I gather from the petition of the Royal Society Council to King Edward VII., which was printed in the *Times* of February 27, that the condition of things which the facts reveal is either unknown to the Council or regarded by them as a matter not worth mentioning.

In that petition His Majesty is informed that the

President and Council are of opinion that the studies which it has been shown were fully provided for by King Charles II.'s charters to the Royal Society, and "taken care of" for, at all events, the first century to which my inquiry was limited, "ought to be taken care of by some academic organisation, and that this should be effected, not by the Royal Society taking charge of these studies, but by the establishment of some other body."

I submit, Sir, that the view that a complete inquiry should be made before any step be taken towards creating a new body to do what the charters of King Charles II. enjoined and empowered the Royal Society to undertake is vastly strengthened by the facts now brought to light, which show us what the Royal Society actually did.

This inquiry was thus referred to in the petition to the King, dated February 14, which was signed by many eminent representatives of the intellectual, industrial and other forces of the Kingdom:—

"We Your Petitioners humbly pray that Your Majesty may be graciously pleased to cause an inquiry to be made with a view of instituting a general and formal organisation of all the studies depending upon scientific method now carried on similar to that inaugurated for the philosophical studies of the seventeenth century by the charters of His Majesty, King Charles II."

I am, Sir, your obedient servant,

NORMAN LOCKYER.

ATHENÆUM CLUB, *March*, 11.

THE EDUCATION OF NAVAL OFFICERS.

(1903.)

The Board of Admiralty are to be entirely congratulated upon their new scheme of entry, education and training of officers.

The most important parts of it are that it shows that, in the opinion of the Admiralty, for the naval service the education obtained by studying things instead of books is essential, and that the scheme set forth is sound and broad in its educational details. The mere existence of it for the purpose intended is certain in time, we believe, to have a profound effect, not only upon the entrance examinations to the Army and the Civil Service, but upon secondary and university education generally. We may go further and say that if the Council of Defence were anything more than a name, the naval scheme would have formed part of a more general one embracing the whole armed service of the country.

Let us see what improvements are proposed upon the present system. First of all, a battleship is to be made more of a fighting unit than it is at present by having all the officers educated alike up to a certain point, whether navigating, gunnery, torpedo, engineer, and those more numerous lieutenants whose duties are not specially devoted to any particular branch, but excepting medical officers and the accountant branch. The Army is a

non-scientific body with scientific corps; the Navy is to be a scientific body all round.

At present, the marine officers enter late after the often soul-destroying training of the ordinary schools which provide the officers of the Army. The engineer officers enter earlier at a special naval engineering establishment. The executive officers enter the *Britannia* at the age of fourteen and a half to fifteen and a half for four terms, and we believe the instruction given in the first three is something like this:—

Mathematics, including Navigation and Chart Work	30½	hours a fortnight.
French	6	,, ,,
Steam	4	,, ,,
Mechanical Drawing	3½	,, ,,
Instruments	3	,, ,,
Physics	1	,, ,,
Naval History	1½	,, ,,
Seamanship	6½	,, ,,

In the fourth term, the cadets are sent for a cruise and are further instructed in practical navigation, instruments and chart work, steam and seamanship.

It will readily be gathered, then, that on the present system, in the schools which furnish the cadets, not much attention need be paid to physical science and the mental training that it brings, if *one hour a fortnight* is all that is provided for it on the *Britannia*.

Under the new scheme, all the officers to whom reference has been made will enter the *Britannia* between the ages of twelve and thirteen, thus saving some two years of ordinary school training. As the age is so low, nomination and a limited competitive examination are preferred to an open examination. This, we consider, is justified,

but some alterations seem desirable with regard to the nominations.

The scheme, in the first place, provides that these nominations are to be limited generally to the First Lord, with certain privileges, elaborately set out, conferred upon individual members of the Board, secretaries, flag officers, commodores and captains. This looks too much as if the Navy were looked upon as an Admiralty preserve. We can imagine, although Sir Michael Hicks-Beach has so far made no revelations with regard to the Navy, that the officers who have to look after promotions may think, as we think, that the nominations should be exclusively in the hands of the First Lord and of the Prime Minister, for it is a question of the whole country with all its interests. The principle of heredity may be pushed too far, for captains will be admirals when their nominees come up for promotion as commanders, and this fact is quite enough, human nature being what it is, to suggest how undesirable the so-called privileges are. Then comes another point. The payment for each cadet entered is 75*l.* per annum, but the Lords of the Admiralty reserve the power of reducing this to 40*l.* in the case ot sons of naval, army or marine officers, or of the civilian staff at the Admiralty.

If the whole Navy and Army, why not the whole Civil Service? and, indeed, why limit the concession to the public services when good cause can be shown for an extension? The more rigid the limitation the less certain the capture of future Nelsons, and the more justification will be given to a possible outcry that the Navy is being made a close preserve for the well to do.

Were the limit extended, a natural sequel would be to

enter originally for the *Britannia* a larger number of boys—say some 30 per cent.—than would be wanted for the service, admitting the required number of these to the service by strict open competition at the end of the *Britannia* period and rejecting the rest. In this way, some objections to the nomination system at entry will be met. If only a few are rejected under the proposed scheme it would be a stigma, whereas if the number is larger it would only be considered a misfortune, and the rejected would have had the best education in England, one fitting them for any walk in life, as we shall show.

We can have nothing but praise for the subjects chosen for the examination for entrance to the *Britannia*, which are as follows :—

PART I.

(1) English (including writing from dictation, simple composition and reproduction of the gist of a short passage twice read aloud to the candidates).

(2) (*a*) History and (*b*) Geography—

(*a*) History (simple questions in English History and growth of the British Empire).

(*b*) Geography (simple questions, with special reference to the British Empire).

(3) French or German (importance will be attached to the oral examination).

(4) (*a*) Arithmetic, and (*b*) Algebra—

(*a*) Arithmetic (elementary, including vulgar and decimal fractions).

(*b*) Algebra to simple equations, with easy problems.

(5) Geometry (to include the subject-matter of the first book of Euclid, or its equivalent in experimental geometry and mensuration. The use of instruments and of algebraical methods will be allowed).

PART II.

(One only to be taken.)

(6) Latin (easy passages for translation from Latin into English and from English into Latin, and simple grammatical questions).

(7) A second modern language (of which, if not French or German,

notice must be previously given), or an advanced examination in the language selected under Part I.

(8) Experimental science (easy questions with the object of testing practical knowledge and powers of observation).

The cadets are to remain four years in the *Britannia*, the instruction comprising an extension of the present course there, and we rejoice at the promise that the present one hour a fortnight for physics is to be replaced by a "thorough elementary instruction in physics and marine engineering, including the use of tools and machines." This, of course, means that there are to be laboratories and practical work, for book-work alone in such subjects is next to useless. Part of this instruction is also to be carried out afloat.

Such a course as this must not only give the cadets a good grounding in the subjects necessary to their profession, but such a mental training as is sure to lead to that brain-power which lies at the root of all good organisation and administration.

After these four years, the cadets will go to sea and become midshipmen. We are told in Lord Selborne's memorandum:—

"Special attention will then be paid to their instruction in mechanics and the other applied sciences and to marine engineering. The instruction of the midshipmen in seamanship will be given, as at present, by an executive officer deputed by the captain; otherwise it will, under the general responsibility of the captain, be supervised by the engineer, gunnery, marine, navigating and torpedo lieutenants of their respective ships; they will be examined annually as to their progress in seamanship, navigation and pilotage, gunnery, torpedo work and engineering, all set papers being, as at present, sent from the Admiralty."

At the end of three years, every midshipman who has passed the qualifying standard at the last annual examination and the final examination in seamanship will

become an acting sub-lieutenant, and if abroad return to England and proceed to the College at Greenwich for a three months' course of mathematics, navigation and pilotage, followed by an examination. Afterwards he goes to Portsmouth for a six months' course in gunnery, torpedo work and engineering, at the close of which he will be examined and on passing out be confirmed in the rank of sub-lieutenant.

How the cadets are to be sent to sea is not yet settled. Either they will serve for the whole three years as midshipmen to battleships and cruisers, ordinarily commissioned, or the first part of this period will be passed in specially commissioned training ships. It is quite decided that at whatever period they are posted to ordinarily commissioned battleships and cruisers, compulsory school on board these ships shall cease.

The young officers who will pass out of the college at Portsmouth between the ages of nineteen and twenty will all have received exactly the same scientific training, and will have had opportunities of displaying their powers of organisation and of dealing with men.

We are not yet told what the common training is to be at Greenwich or at Portsmouth. We believe the present course for sub-lieutenants is somewhat as follows:—

PART I.

Length of course		8 weeks	
Mathematics	Trigonometry, Mechanics, Navigation, Instruments.	21	hours a week.
Steam		2	"
French		2	"
Surveying		3	"
Physics		3	"
		31	

PART II.

Length of course		11 weeks.
Mathematics	Advanced Pure Maths., Statics, Hydrostatics, Dynamics, Navigation.	27 hours a week.
Physics		1 hour lecture. 3 ,, practical.
		31

PILOTAGE.

Length of course	6 weeks
28 hours a week.	

Now the differentiation begins. It seems to be as follows :—

Executive officers - Special navigation, ,, gunnery, ,, torpedo, Unspecialised,

Engineer officers,
Royal Marine officers,

and the object to be kept in view is stated to be to make them fit to perform those specialised duties which are the product of modern science; nothing is said about those officers who have no specialised duties.

The Executive Branch.

On this differentiation, all officers ranking as sub-lieutenants will go to sea for two years.

The next phase is that after two years at sea all the executive sub-lieutenants will be promoted to the rank of lieutenant on gaining the same qualifying watch-keeping certificate as at present. All those who have passed their examinations exceptionally well will, as now, receive accelerated promotion. Then comes a selection by the Admiralty of those among them who are

to be trained as specialists in gunnery, torpedo work, or navigation; these will go to the Royal Naval College at Greenwich for special courses. We presume that this "selection" for training as specialists represents a promotion for those so selected.

After five years' seniority in the rank of lieutenant, all officers will have to pass an examination for promotion to the rank of commander in certain technical subjects.

These are :—

Court-martial procedure,
International law,
Knowledge of British and foreign warships, guns, torpedoes, &c.,
Naval history,
Signals,
Strategy,
Tactics and battle formation.

This examination as it exists at present in the scheme is to be undergone alike by those who are engaged in the specialised scientific duties in the ship, with all their responsibilities, and those—under existing practice a much larger number—who have under the scheme no specialised scientific duties. Now, it is obvious that these latter will be under much better conditions for preparing for an examination, and that the former will have no opportunity of letting their specialised duties tell in the examination, so that the effect of it will be to favour the promotion of those who were not selected to perform specialised duties.

The Engineer Branch.

On this differentiation, the engineer officers, sub-lieutenants about the age of nineteen, instead of going to sea for two years like the executive officers, will go to the college at Keyham for a professional course, the

exact duration of which will be subsequently determined. At the expiration of this course a proportion will be selected to go to Greenwich for a further course, while the remainder go to sea. They will then, if found qualified, all be promoted to be lieutenants under the same conditions as the executives. The nature and duration of the special course at Greenwich will be very carefully determined, and an opportunity will be afforded to those officers selected for it to make themselves acquainted with the latest developments of engineering science, not only at Greenwich but at the great civil engineering establishments and institutions which are to be found in the country.

The engineers are now to be put on an equality with the executive officers, the ranks and uniform being assimilated, but with a difference, for while the executive officers specially trained for navigation (N), gunnery (G), and torpedo (T) lose these letters when promoted to be captains, the engineers are to retain the special (E) to the rank of Rear-Admiral (E), and as a solatium for not being allowed to command a ship are to receive higher pay and are promised "high appointments." Whether this arrangement will be carried out when the time comes, some twenty years hence, the future will show. In all the discussions on the complexity of the machinery of the modern man-of-war, the, as great or greater, complexity of the old sailing three-decker seems to have been entirely lost sight of.

The Royal Marines.

With regard to the sub-lieutenants drafted to the Royal Marines, we read as follows :—

"After his final examination as sub-lieutenant along with the future

executive and engineer officer, the young Royal Marine officer will receive his special military training during the next two years partly at the college at Greenwich and partly at the headquarters of divisions or the depôt; the training of all these officers will be extended so as to correspond more closely to the training now received by the young officers of the Royal Marine Artillery; and after this two years' training, the young Marine officer will receive the rank and pay of lieutenant of marines so as to put him financially on an equality with the executive sub-lieutenant. As in the case of the executive lieutenants, specially good officers will qualify as gunnery and torpedo lieutenants, provided that they have kept watch at sea for one year, have passed the test examination for qualifying for gunnery and torpedo lieutenants, and have been specially selected and recommended. . . . The future Royal Marine officer will thus become available for keeping watch at sea and for general executive duties on board ship up to and including the rank of captain of marines."

Such is a short abstract of a scheme which we believe will be of the utmost value to the Naval Service. Educationally and scientifically, it has so much to recommend it that its authors, and chief among them, Lord Rosebery tells us, we must hold Sir John Fisher, are to be warmly congratulated.

Only one conclusion can be drawn from the scheme as a whole; many of the anticipated difficulties will have vanished before it comes into full operation some ten years hence, and the effect of the practical work in pure science now to be generally introduced for the first time, and the opportunities the officers will have of becoming acquainted and being responsible for every class of duty, both scientific and administrative, will weld them into a homogeneous body, each member of which should have had his brain-power so thoroughly developed that the greatest scientific skill will generally be combined with the highest powers of organisation. At present, it would seem, the very opposite is the case, for otherwise the

present Admiralty system of promotions cannot be defended. Nor is the difference in the treatment of the various branches limited to the promotions. Certain lieutenants are at present selected for certain specially scientific duties; this leaves a large residuum not so selected. Special allowances are given to the navigating, gunnery and torpedo lieutenants in a ship, but the first lieutenant, who may be taken as the representative of the large body of non-specialists, not only gets a smaller allowance, but has to spend money in eking out the Admiralty's meagre supply of paint.

The allowance paid to the navigating officer is the highest, and it might be assumed, therefore, that his duties are considered important; but what happens to him? We are informed that of 187 commanders promoted captains between June, 1892, and June, 1902, only sixteen, that is one in eleven, have specially studied navigation and all that navigation means, and had the real handling of battleships in tactical exercises. Further, that these sixteen have been promoted so late that none of them, in ordinary circumstances, can become admirals on the active list.

Recent sad experiences both with flag-ships and smaller craft—100 "accidents" to torpedo boats and t.b.d.'s in two years—have taught us that the best admiral and the best commander, even of a torpedo boat, will be he who knows most about what ships can do in various circumstances and how to make them do it. The most instructed navigator will always be the safest tactician. Leading a great fleet into action and drilling men in the duties performed in a single ship are vastly different affairs.

The present system, however, as we have seen, bars the promotion of a navigating officer to the higher ranks. So that all the admirals, the future leaders of our battle fleets, eventually to be selected from among the 187 captains to whom we have referred, will be the least instructed and least practised in navigation and all that navigation means in the way of handling ships.

We are told that information with regard to the promotion of gunnery and torpedo officers is much more difficult to obtain, but this is of little importance, as their functions are necessarily limited to single ships and can have no bearing on tactics or the leading of fleets into action.

To the plain man, this result seems curious. Other reasons than that we have suggested have been given, but whatever the reason may be—we are not concerned either to attack or defend the Admiralty—we may hope that under the new system the apparent paradox will disappear, and it seems a pity to wait until then.

There is one part of the scheme of instruction which calls for criticism in a scientific journal. We read of special schools of gunnery, engineering and torpedo work, but no school of navigation is referred to.

It is a question whether an officer who has been generally trained and has been six years at sea will derive any benefit from going to a land college to learn navigation. What is really wanted to complete the scheme on true scientific lines is a navigation school afloat at this period of the officer's career where each member of the batch could take charge, under proper supervision of course, not only in tideways and strong currents, among traffic and in entering and leaving harbours, but also in the open Atlantic.

This condition might be utilised by sending Marconi ethergrams, which would not only enable the Meteorological Office vastly to improve its service, but would give the young officers an interest in meteorology, a science which is still important to those who go to sea, though we find no reference to it in the memorandum.

Another important point that would be gained by this method of procedure would be to teach the officer that the roll of his ship will depend to some extent upon its presentation to the sea running at the time, so that there will be courses on which the fighting platform can be made more stable than on others. With homogeneous fleets, this may replace the "getting to windward" of old days preparatory to a naval engagement.

When we pass from the criticism of the new arrangements to the first steps actually taken to give effect to them, the opinion is quite general that the Admiralty is to be entirely congratulated. Prof. Ewing, who may be looked upon as the creator of the admirable engineering school at Cambridge, thereby showing that his powers of administration and organisation are on a par with his scientific acquirements, has been selected to fill the post of Director-General of Naval Instruction; his duty, we take it, will, to a large extent, be to do for the *personnel* what the Director of Naval Construction does for the *matériel* of the fleet.

We may be convinced not only that with such a strong man as this at the helm the complete scientific instruction of officers will be insisted upon, but that practical laboratory instruction of the juniors in mathematics and pure science will be secured.

Indeed, we may go further, and say that they have

already been secured in most admirable fashion, for Lord Selborne, in the speech to which we have already referred, spoke as follows :—

"Without pledging myself to exact detail, I will give a general sketch of the kind of education that will be given. It includes not only that special education for which the school will exist, but that general education which every officer and gentleman ought to have. History, geography, physical geography, English and French will be taught. I do not say that other modern languages will not be taught. Mathematics, algebra, arithmetic, trigonometry, mechanics, physics, laboratory work, seamanship, drill and engineering will be taught. There will be laboratories and workshops in which the boys will be accustomed to the use of tools from the very commencement. There will be vessels of all sorts for use and demonstration, from a launch to a battleship, and generally an effort will be made, while not neglecting the general education of the boys, to start them from the moment of their entering the college on the education of a naval officer."

When we compare this programme with the one hour a fortnight in physics in the *Britannia*, and no laboratory within sight, students of science well recognise that naval education for the future will be conducted on business principles, and we may again express our regret that such a system, *mutatis mutandis*, is still a thing to hope for in some dim distant future in the case of the Army.

It has already been pointed out how the subject of navigation suffered generally from the absence of a school afloat for practical work similar to those provided long ago for gunnery and torpedo work. Not only is this defect in the system to disappear in the case of the junior officers, but as stated in the circular letter to which we have referred, the regulations for the instruction of navigating officers have been revised so that a definite course of practical training may be given them in a navigation school ship which is about to be established at Portsmouth, with a suitable staff of

instructors. The course of instruction while they are attached to the school ship will last for ninety working days, part of the time being spent at sea in the ship and the remainder on shore. While going through the course they will live on the school ship.

After the candidates have qualified in the school they will serve for a short period in the large ships of the Mediterranean, Home and Channel fleets, so as to obtain experience under the navigating officers in the work of a fleet in regard to navigating duties.

It would be difficult to overestimate the importance of these new departures, about which very little has been said in the various discussions of the new scheme, although, in our opinion, they are precisely those by which the greatest benefit to the service will be secured in the future.

Leaving on one side the objections to the new scheme which have been based on prejudice or a complete ignorance of the changes in any naval service which the progress of science has rendered inevitable, we may say that the question of the possible interchangeability of the officers at some distant date has attracted most attention in relation to the new training of the engineers. On this point opinion has rapidly grown in favour of the new scheme, since inquiry has shown what a large common basis of pure science underlies the proper performance of any one of the specialised duties. The objections, in short, have been held by advocates of technical education in its worst sense, that is, the rule-of-thumb carrying out of practical processes without any inkling of the scientific principles involved.

Although the new scheme provides for a system of

interchangeability when once it is in full working order, the present practice is vastly different, and as we consider this interchangeability of paramount importance from the point of view of utilising to the utmost the results of the complete scientific instruction of our naval officers to be provided in future. It is important to return to this subject in somewhat fuller detail to show the important bearing of another part of the new circular.

We may begin by saying that our present naval officers, so far as their *scientific* training goes, may be divided into two categories, well trained and less trained; these are the equivalents of the "specialised" and "not specialised" of the Admiralty memorandum setting forth the scheme.

The well-trained or specialised officers have to deal with (1) navigation (but so far without a navigating school), (2) gunnery with a gunnery school, and (3) torpedoes with a torpedo school. We may say that the lieutenants performing these specialised duties comprise roughly about one-third of the total numbers. They get special allowances for their special duties.

But it must at once be stated that there are many duties on board ship for the proper performance of which special training, not of a scientific character in the ordinary acceptation of the word, is equally required, and, of course, these duties have to be provided for. They are carried on by the "unspecialised" lieutenants, who are roughly twice as numerous as those who have received a full scientific training. These are employed as watch keepers and in connection with general ship duties. They are "deck officers" as opposed to the scientific officers. The less scientifically trained or deck officer gets little or no

allowance; on the other hand he is expected to spend money in painting ship. We see then that under the present system the officers performing each particular piece of work, whether scientific or merely professional, are for the most part in water-tight compartments; there are differences in the amount of special instruction they receive, the kind of work they do and the allowances they get.

According to the present practice the less scientifically trained officers get the lion's share of promotion; that, in fact, the promotion has been in the inverse ratio of the scientific nature of the work done.

It has been urged in defence of this practice that scientific knowledge is of less value in the higher ranks than that which is derived from a complete mastery of all the details of a ship's general organisation, which can only be gained by the constant performance of the "deck duties" to which reference has been made. So that if we take the navigator, the most important scientific officer, on the one hand, and the first lieutenant, the most important deck officer, on the other, the thing works out in this way. The navigator, because his duties are so onerous and are never changed, knows nothing of deck duties. The first lieutenant, because his duties are never changed, is unlikely ever to become a competent navigator. The navigator, because he has not had an opportunity of learning deck duties, has his promotion retarded so that he can never get on the active list of admirals. The first lieutenant, because he is necessarily familiar with deck duties, is the first to be promoted, and is thus sure of employment on the active list of admirals.

The baneful effects of such a system as this, which are

twofold, have already been fully set out. The Admiralty indicated its contempt for scientific as opposed to mere professional training, and the admirals' list was swamped by men who knew little of navigation, although this, of course, finds one of its highest outcomes in handling ships in tactical exercises and in order of battle.

It was next shown that while, as determined by the scheme, the interchangeability of all officers, including the engineer officers, *must* be secured ten years hence, there were reasons why the interchangeability of at least some of the duties of the existing executive officers should be commenced at once. We rejoice to learn from the new circular that this also is to be done.

Lieutenants (N.) will in future be placed on exactly the same footing as regards executive command and ship's duty generally as gunnery and torpedo lieutenants, and are not to be excused from any ship's duties except those which interfere with the special duties pertaining to them. They will be appointed and succeed to the position of first lieutenant, if a vacancy occurs, in all ships where a commander is borne exactly in the same manner as any other specialist officer.

In rendering the special report on the qualifications of a navigating officer, a further clause is to be added, dealing with his capabilities as an executive officer.

Further, midshipmen who show special aptitude are, whenever possible when the ship is under way, to be taken off other duties, and to navigate the ship independently from the after bridge, fixing positions on the chart and bringing the result of such work to the navigating officer.

Instead of one commissioned officer taking sights and working the reckoning daily, arrangements are to be made,

when practicable, for one junior lieutenant or sub-lieutenant to be taken partially off watch-keeping so as to work with the navigating officer for ten working days under way.

The officer thus told off is to be on deck when coasting, making the land, going in and out of harbour, etc., and is to be in every way encouraged to get an insight into navigating duties. If at the end of the ten days the captain is satisfied with his work, he will be relieved and another officer is to be told off for this duty.

These important changes can be urged on two grounds. In the first place, there is the obvious benefit to the Service which will be secured when all captains and admirals are made equally acquainted with both their scientific and professional duties by interchanging them while they are lieutenants and commanders. In the second place, the preparation and simplification of the carrying out of the new scheme, by which another class of specialised officers, the engineers, will be introduced in the future, will be vastly facilitated by organising and testing the best way of interchanging duties on a small scale over a limited area.

We have referred chiefly to the navigator among the scientific officers, and no doubt the Admiralty has dealt with him first, because his duties are the most specialised; but if the interchange is advantageous in his case, the other specialists will follow, and, speaking only from the scientific side, knowing nothing of professional difficulties to be surmounted, it seems to us that such a preliminary experimental study of the problem which awaits the Admiralty in the future, and which, if faced along the whole line, at the same time, may prove of Herculean

proportions and be fraught with dangers of breakdowns, must commend itself as a scientific method. Our view of the wisdom of such an interchangeability among the present officers is strengthened by information which has been furnished us as to the procedure in the German Navy, which enables us to compare the two systems, and in our opinion fully justifies the policy of the new circular.

The distribution of duties amongst executive officers of the German Navy is as follows. As in the British Service every officer is educated in seamanship, navigation, gunnery and torpedo service. In the course of their service the various qualifications of the officers are carefully noted, and especially if they show superiority in any one of the above-mentioned branches. Ships in the German Navy are commissioned for two years. The list of officers for any given ship is made out by the Admiralty at Berlin. The next senior officer after the captain becomes the executive officer. After him the officer who is most proficient (according to the returns) in navigation and pilotage is appointed as navigating officer, without regard to seniority as lieutenant. He who is most proficient in gunnery is appointed "artillery officer," and so with the torpedo officer. Qualification regulates the selection of each officer for special duties, not his seniority as lieutenant. The specialisation of an officer for any particular duty only lasts for the two years' commission. In the next commission the navigating officer may be artillery or torpedo officer, or an ordinary watch keeper without special duty. It is *exceedingly rare* for an officer to be appointed for navigating duties *for more than two years*, as the Admiralty require every officer to go through a probation as navigator *in order*

to ensure that captains who are responsible for the navigation of the ship shall know their work in that respect. An apparently weak point in this system is that for a time after the appointment of an officer to navigating duties ships are not so well navigated as they might be, since for the first few months of his time the navigator is really learning his work. Gunnery and torpedo work may be learnt in harbour, but navigating can *only* be learnt by actual practice and experience at sea. But, on the other hand, the strength of this system is that all officers have practical training at sea as navigators *with a captain who has gone completely through the navigating mill* and knows how to detect any failure in the navigator which might endanger the ship. For squadrons an officer who has shown good ability as navigator in a single ship is selected as navigator.

On this system, whilst ability in any branch (N., G., or T.) is recognised, an officer is not unduly specialised to the detriment of his knowledge in other branches of his profession. In the British Navy the gunnery and torpedo officers are occupied with their special duties nearly the whole of their time as lieutenants, but they go to deck duties when promoted commander, although their knowledge of navigation and the handling of the larger ships is practically nil. But the navigator is occupied in special duties when promoted commander as well as during his service as lieutenant, *some fifteen years in all at least*, and is allowed no practice in other branches of a naval officer's profession, and because he has not been allowed to have any such practice, he is discharged to the coast guard, his naval career is broken, and the service loses a man who has had the best possible training for leading ships into action.

Surely this comparison shows that the question of interchangeability has already been considered in the German Navy on the lines which we indicated as beneficial for our own; and in this we see an additional argument why the preliminary trial which we suggested on scientific grounds in our own Navy, and to which the Admiralty now stands committed, should at all events be welcomed as a first step to the wider interchangeability to which the Admiralty is certain to be forced in the future, for of the progress and need of science in the armed service of a nation there will be no end.

THE INFLUENCE OF BRAIN-POWER ON HISTORY.*

(1903.)

My first duty to-night is a sad one. I have to refer to a great loss which this nation and this Association have sustained. By the death of the great Englishman and great statesman who has just passed away we members of the British Association are deprived of one of the most illustrious of our Past-Presidents. We have to mourn the loss of an enthusiastic student of science. We recognise that as Prime Minister he was mindful of the interests of science, and that to him we owe a more general recognition on the part of the State of the value to the nation of the work of scientific men. On all these grounds you will join in the expression of respectful sympathy with Lord Salisbury's family in their great personal loss, which your Council has embodied this morning in a resolution of condolence.

Last year, when this friend of science ceased to be Prime Minister, he was succeeded by another statesman who also has g'ven many proofs of his devotion to philosophical studies, and has shown in many utterances that he has a clear understanding of the real place of science

* Presidential Address at the British Association Meeting at Southport in 1903.

in modern civilisation. We, then, have good grounds for hoping that the improvement in the position of science in this country which we owe to the one will also be the care of his successor, who has honoured the association by accepting the unanimous nomination of your Council to be your President next year, an acceptance which adds a new lustre to this Chair.

On this we may congratulate ourselves all the more because I think, although it is not generally recognised, that the century into which we have now well entered may be more momentous than any which has preceded it, and that the present history of the world is being so largely moulded by the influence of brain-power, which in these modern days has to do with natural as well as human forces and laws, that statesmen and politicians will have in the future to pay more regard to education and science as empire-builders and empire-guarders than they have paid in the past.

The nineteenth century will ever be known as the one in which the influences of science were first fully realised in civilised communities; the scientific progress was so gigantic that it seems rash to predict that any of its successors can be more important in the life of any nation.

Disraeli, in 1873, referring to the progress up to that year, spoke as follows :—

> "How much has happened in these fifty years—a period more remarkable than any, I will venture to say, in the annals of mankind. I am not thinking of the rise and fall of Empires, the change of dynasties, the establishment of Governments. I am thinking of those revolutions of science which have had much more effect than any political causes, which have changed the position and prospects of mankind more than all the conquests and all the codes and all the legislators that ever lived."*

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* *Nature*, November 27, 1873, vol. ix. p. 71.

The progress of science, indeed, brings in many considerations which are momentous in relation to the life of any limited community—any one nation. One of these considerations to which attention is now being greatly drawn is that a relative decline in national wealth derived from industries must follow a relative neglect of scientific education.

It was the late Prince Consort who first emphasised this when he came here fresh from the University of Bonn. Hence the "Prince Consort's Committee," which led to the foundation of the College of Chemistry and afterwards of the Science and Art Department. From that time to this the warnings of our men of science have become louder and more urgent in each succeeding year. But this is not all; the commercial output of one country in one century as compared with another is not alone in question; the acquirement of the scientific spirit and a knowledge and utilisation of the forces of Nature are very much further reaching in their effects on the progress and decline of nations than is generally imagined.

Britain in the middle of the last century was certainly the country which gained most by the advent of science, for she was then in full possession of those material gifts of Nature, coal and iron, the combined winning and utilisation of which, in the production of machinery and in other ways, soon made her the richest country in the world, the seat and throne of invention and manufacture, as Mr. Carnegie has called her. Being the great producers and exporters of all kinds of manufactured goods, we became eventually, with our iron ships, the great carriers, and hence the supremacy of our mercantile marine and our present command of the sea.

The most fundamental change wrought by the early applications of science was in relation to producing and carrying power. With the winning of mineral wealth and the production of machinery in other countries, and cheap and rapid transit between nations, our superiority as depending upon our first use of vast material resources was reduced. Science, which is above all things cosmopolitan—planetary, not national—internationalises such resources at once. In every market of the world

> "things of beauty, things of use,
> Which one fair planet can produce,
> Brought from under every star,"

were soon to be found.

Hence the first great effect of the general progress of science was relatively to diminish the initial supremacy of Britain due to the first use of *material* resources, which indeed was the real source of our national wealth and place among the nations.

The unfortunate thing was that, while the foundations of our superiority depending upon our *material resources* were being thus sapped by a cause *which was beyond our control*, our statesmen and our Universities were blind leaders of the blind, and our other asset, our mental resources, which was within our control, was culpably neglected.

So little did the bulk of our statesmen know of the part science was playing in the modern world and of the real basis of the nation's activities that they imagined political and fiscal problems to be the only matters of importance. Nor, indeed, are we very much better off to-day. In the important discussions recently raised by Mr. Chamberlain next to nothing has been said of the effect of the

progress of science on prices. The whole course of the modern world is attributed to the presence or absence of taxes on certain commodities in certain countries. The fact that the great fall in the price of food-stuffs in England did not come till some thirty or forty years after the removal of the corn duty between 1847 and 1849 gives them no pause; for them new inventions, railways and steamships are negligible quantities; the vast increase in the world's wealth, in Free Trade and Protected countries alike, comes merely, according to them, in response to some *political* shibboleth.

We now know, from what has occurred in other States, that if our Ministers had been more wise and our Universities more numerous and efficient, our *mental resources* would have been developed by improvements in educational method, by the introduction of science into schools, and, more important than all the rest, by the teaching of science by experiment, observation and research, and not from books. It is because this was not done that we have fallen behind other nations in properly applying science to industry, so that our applications of science to industry are relatively less important than they were. But this is by no means all; we have lacked the strengthening of the national life produced by fostering the scientific spirit among all classes and along all lines of the nation's activity; many of the responsible authorities know little and care less about science; we have not learned that it is the duty of a State to organise its forces as carefully for peace as for war; that Universities and other teaching centres are as important as battleships or big battalions; are, in fact, essential parts of a modern State's machinery, and, as such, to be equally

aided and as efficiently organised to secure its future well-being.

Now the objects of the British Association as laid down by its founders seventy-two years ago are "To give a stronger impulse and a more systematic direction to scientific inquiry—to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers—to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress."

In the main, my predecessors in this Chair, to which you have done me the honour to call me, have dealt, and with great benefit to science, with the objects first-named.

But at a critical time like the present I find it imperative to depart from the course so generally followed by my predecessors and to deal with the last object named, for unless by some means or other we "obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress," we shall suffer in competition with other communities in which science is more generally utilised for the purposes of the national life.

The Struggle for Existence in Modern Communities.

Some years ago, in discussing the relations of scientific instruction to our industries, Huxley pointed out that we were in presence of a new "struggle for existence," struggle which, once commenced, must go on until only the fittest survives.

It is a struggle between organised species—nations—not between individuals or any class of individuals. It

is, moreover, a struggle in which science and brains take the place of swords and sinews, on which depended the result of those conflicts which, up to the present, have determined the history and fate of nations. The school, the University, the laboratory and the workshop are the battlefields of this new warfare.

But it is evident that if this, or anything like it, be true, our industries cannot be involved alone; the scientific spirit, brain-power, must not be limited to the workshop if other nations utilise it in all branches of their administration and executive.

It is a question of an important change of front. It is a question of finding a new basis of stability for the Empire in face of new conditions. I am certain that those familiar with the present state of things will acknowledge that the Prince of Wales's call, 'Wake up,' applies quite as much to the members of the Government as it does to the leaders of industry.

What is wanted is a complete organisation of the resources of the nation, so as to enable it best to face all the new problems which the progress of science, combined with the ebb and flow of population and other factors in international competition, are ever bringing before us. Every Minister, every public department, are involved; and this being so, it is the duty of the whole nation—King, Lords and Commons—to do what is necessary to place our scientific institutions on a proper footing in order to enable us to "face the music," whatever the future may bring. The idea that science is useful only to our industries comes from want of thought. If anyone is under the impression that Britain is only suffering at present from the want of the scientific spirit among our

industrial classes, and that those employed in the State service possess adequate brain-power and grip of the conditions of the modern world into which science so largely enters, let him read the Report of the Royal Commission on the War in South Africa. There he will see how the whole "system" employed was, in Sir Henry Brackenbury's words applied to a part of it, "*unsuited to the requirements of an army which is maintained to enable us to make war.*" Let him read also in the Address of the President of the Society of Chemical Industry what drastic steps had to be taken by Chambers of Commerce and "a quarter of a million of working-men" to get the Patent Law Amendment Act into proper shape in spite of all the advisers and officials of the Board of Trade. Very few people realise the immense number of scientific problems the solution of which is required for the State service. The nation itself is a gigantic workshop; and the more our rulers and legislators, administrators and executive officers possess the scientific spirit, the more the rule of thumb is replaced in the State service by scientific methods, the more able shall we be, thus armed at all points, to compete successfully with other countries along all lines of national as well as of commercial activity.

It is obvious that the power of a nation for war, in men and arms and ships, is one thing; its power in the peace struggles to which I have referred is another. In the latter the source and standard of national efficiency are entirely changed. To meet war conditions, there must be equality or superiority in battleships and army corps. To meet the new peace conditions, there must be equality or superiority in Universities, scientific organisation and everything which conduces to greater brain-power.

Our Industries are Suffering in the Present International Competition.

The present condition of the nation, so far as its industries are concerned, is as well known, not only to the Prime Minister, but to other political leaders in and out of the Cabinet, as it is to you and to me. Let me refer to two speeches delivered by Lord Rosebery and Mr. Chamberlain on two successive days in January 1901.

Lord Rosebery spoke as follows :—

> ". . . The war I regard with apprehension is the war of trade which is unmistakably upon us. . . . When I look round me I cannot blind my eyes to the fact that, so far as we can predict anything of the twentieth century on which we have now entered, it is that it will be one of acutest international conflict in point of trade. We were the first nation of the modern world to discover that trade was an absolute necessity. For that we were nicknamed a nation of shopkeepers ; but now every nation wishes to be a nation of shopkeepers too, and I am bound to say that when we look at the character of some of these nations, and when we look at the intelligence of their preparations, we may well feel that it behoves us not to fear, but to gird up our loins in preparation for what is before us."

Mr. Chamberlain's views were stated in the following words :—

> "I do not think it is necessary for me to say anything as to the urgency and necessity of scientific training. . . . It is not too much to say that the existence of this country, as the great commercial nation, depends upon it. . . . It depends very much upon what we are doing now, at the beginning of the twentieth century, whether at its end we shall continue to maintain our supremacy or even equality with our great commercial and manufacturing rivals."

All this refers to our industries. We are suffering because trade no longer follows the flag as in the old days, but because trade follows the brains, and our manufacturers are too apt to be careless in securing them. In one chemical establishment in Germany 400 doctors of

science, the best the universities there can turn out, have been employed at different times in late years. In the United States the most successful students in the higher teaching centres are snapped up the moment they have finished their course of training, and put into charge of large concerns, so that the idea has got abroad that youth is the password of success in American industry. It has been forgotten that the latest product of the highest scientific education must necessarily be young, and that it is the training and not the age which determines his employment. In Britain, on the other hand, apprentices who can pay high premiums are too often preferred to those who are well educated, and the old rule-of-thumb processes are preferred to new developments—a conservatism too often depending upon the master's own want of knowledge.

I should not be doing my duty if I did not point out that the defeat of our industries one after another, concerning which both Lord Rosebery and Mr. Chamberlain express their anxiety, is by no means the only thing we have to consider. The matter is not one which concerns our industrial classes only, for knowledge must be pursued for its own sake; and since the full life of a nation with a constantly increasing complexity, not only of industrial, but of high national aims, depends upon the universal presence of the scientific spirit—in other words, brain-power—our whole national life is involved.

The Necessity for a Body dealing with the Organisation of Science.

The present awakening in relation to the nation's real needs is largely due to the warnings of men of science.

But Mr. Balfour's terrible Manchester picture of our present educational condition* shows that the warning, which has been going on now for more than fifty years, has not been forcible enough; but if my contention that other reorganisations besides that of our education are needed is well founded, and if men of science are to act the part of good citizens in taking their share in endeavouring to bring about a better state of things, the question arises, Has the neglect of their warnings so far been due to the way in which these have been given?

Lord Rosebery, in the address to a Chamber of Commerce from which I have already quoted, expressed his opinion that such bodies do not exercise so much influence as might be expected of them. But if commercial men do not use all the power their organisation provides, do they not by having built up such an organisation put to shame us students of science, who are still the most disorganised members of the community?

Here, in my opinion, we have the real reason why the scientific needs of the nation fail to command the attention either of the public or of successive Governments. At present, appeals on this or on that behalf are the appeals of individuals; science has no collective voice on the larger national questions; there is no organised body which formulates her demands.

During many years it has been part of my duty to consider such matters, and I have been driven to the conclusion that our great crying need is to bring about an

* "The existing educational system of this country is chaotic, is ineffectual, is utterly behind the age, makes us the laughing-stock of every advanced nation in Europe and America, puts us behind, not only our American cousins, but the German and the Frenchman and the Italian."—*The Times*, October 15, 1902.

organisation of men of science and all interested in science similar to those which prove so effective in other branches of human activity. For the last few years I have dreamt of a Chamber, Guild, League, call it what you will, with a wide and large membership, which should give us what, in my opinion, is so urgently needed. Quite recently I sketched out such an organisation, but what was my astonishment to find that I had been forestalled, and by the founders of the British Association.

The British Association such a Body.

At the commencement of this Address I pointed out that one of the objects of the Association, as stated by its founders, was "to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress."

Everyone connected with the British Association from its beginning may be congratulated upon the magnificent way in which the other objects of the Association have been carried out; but as one familiar with the association for the last forty years I cannot but think that the object to which I have specially referred has been too much overshadowed by the work done in connection with the others.

A careful study of the early history of the Association leads me to the belief that the function I am now dwelling on was strongly in the minds of the founders; but be this as it may, let me point out how admirably the organisation is framed to enable men of science to influence public opinion and so to bring pressure to bear upon Governments which follow public opinion. (1) Unlike all the other chief metropolitan societies, its outlook is not limited

to any branch or branches of science. (2) We have a wide and numerous fellowship, including both the leaders and the lovers of science, in which all branches of science are and always have been included with the utmost catholicity—a condition which renders strong committees possible on any subject. (3) An annual meeting at a time when people can pay attention to the deliberations, and when the newspapers can print reports. (4) The possibility of beating up recruits and establishing local committees in different localities, even in the King's dominions beyond the seas, since the place of meeting changes from year to year, and is not limited to these islands.

We not only, then, have a scientific Parliament competent to deal with all matters, including those of national importance, relating to science, but machinery for influencing all new councils and committees dealing with local matters, the functions of which are daily becoming more important.

The machinery might consist of our Corresponding Societies. We already have affiliated to us seventy societies with a membership of 25,000. Were this number increased so as to include every scientific society metropolitan and provincial, in the Empire, we might eventually hope for a membership of half a million.

I am glad to know that the Council is fully alive to the importance of giving a greater impetus to the work of the corresponding societies. During this year a committee was appointed to deal with the question; and later still, after this committee had reported, a conference was held between this committee and the Corresponding Societies' Committee to consider the suggestions made,

some of which will be gathered from the following extract:—

"In view of the increasing importance of science to the nation at large, your committee desire to call the attention of the Council to the fact that in the corresponding societies the British Association has gathered in the various centres represented by these societies practically all the scientific activity of the provinces. The number of members and associates at present on the list of the corresponding societies approaches 25,000, and no organisation is in existence anywhere in the country better adapted than the British Association for stimulating, encouraging and co-ordinating all the work being carried on by the seventy societies at present enrolled. Your committee are of opinion that further encouragement should be given to these societies and their individual working members by every means within the power of the Association; and with the object of keeping the corresponding societies in more permanent touch with the Association they suggest than an official invitation on behalf of the Council be addressed to the societies, through the Corresponding Societies' Committee, asking them to appoint standing British Association sub-committees, to be elected by themselves, with the object of dealing with all those subjects of investigation common to their societies and to the British Association committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centres. . .

"Your committee desire to lay special emphasis on the necessity for the extension of the scientific activity of the corresponding societies and the expert knowledge of many of their members in the direction of scientific education. They are of opinion that immense benefit would accrue to the country if the corresponding societies would keep this requirement especially in view with the object of securing adequate representation for scientific education on the Education Committees now being appointed under the new Act. The educational section of the Association having been but recently added, the corresponding societies have as yet not had much opportunity for taking part in this branch of the Association's work; and in view of the re-organisation in education now going on all over the country your committee are of opinion that no more opportune time is likely to occur for the influence of scientific organisations to make itself felt as a real factor in national education. . ."

I believe that if these suggestions or anything like them—for some better way may be found on inquiry—

are accepted, great good to science throughout the Empire will come. Rest assured that sooner or later such a Guild will be formed, because it is needed. It is for you to say whether it shall be, or form part of, the British Association. We in this Empire certainly need to organise science as much as in Germany they find the need to organise a navy. The German Navy League, which has branches even in our Colonies, already has a membership of 630,000 and its income is nearly £20,000 a year. A British Science League of 500,000 with a sixpenny subscription would give us £12,500 a year, quite enough to begin with.

I for one believe that the British Association would be a vast gainer by such an expansion of one of its existing functions. Increased authority and prestige would follow its increased utility. The meetings would possess a new interest; there would be new subjects for reports; missionary work less needed than formerly would be replaced by efforts much more suited to the real wants of the time. This magnificent, strong and complicated organisation would become a living force, working throughout the year instead of practically lying idle, useless and rusting for fifty-one weeks out of the fifty-two so far as its close association with its members is concerned.

If this suggestion in any way commends itself to you, then when you begin your work in your sections or General Committee see to it that a body is appointed to inquire how the thing can be done. Remember that the British Association will be as much weakened by the creation of a new body to do the work I have shown to have been in the minds of its founders as I believe

it will be strengthened by becoming completely effective in every one of the directions they indicated, and for which effectiveness we, their successors, are indeed responsible. The time is appropriate for such a reinforcement of one of the wings of our organisation, for we have recently included Education among our sections.

There is another matter I should like to see referred to the committee I have spoken of, if it please you to appoint it. The British Association—which, as I have already pointed out, is now the chief body in the Empire which deals with the totality of science—is, I believe, the only organisation of any consequence which is without a charter, and which has not His Majesty the King as patron.

The First Work of such an Organisation.

I suppose it is my duty, after I have suggested the need of organisation, to tell you my personal opinion as to the matters where we suffer most in consequence of our lack of organisation at the present time.

Our position as a nation, our success as merchants, are in peril chiefly—dealing with preventable causes—because of our lack of completely efficient Universities and our neglect of research. This research has a double end. A professor who is not learning cannot teach properly or arouse enthusiasm in his students; while a student of anything who is unfamiliar with research methods and without that training which research brings, will not be in the best position to apply his knowledge in after-life. From neglect of research comes imperfect education and a small output of new applications and new knowledge to reinvigorate our industries. From

imperfect education comes the unconcern touching scientific matters and the too frequent absence of the scientific spirit in the nation generally, from the Court to the Parish Council.

I propose to deal as briefly as I can with each of these points.

Universities.

I have shown that, so far as our industries are concerned, the cause of our failure has been run to earth; it is fully recognised that it arises from the insufficiency of our Universities both in numbers and efficiency, so that not only our captains of industry, but those employed in the nation's work generally, do not secure a training similar to that afforded by other nations. No additional endowment of primary, secondary or technical instruction will mend matters. This is not merely the opinion of men of science; our great towns know it, our ministers know it.

It is sufficient for me to quote Mr. Chamberlain:—

"It is not everyone who can, by any possibility, go forward into the higher spheres of education; but it is from those who do that we have to look for the men who in the future will carry high the flag of this country in commercial, scientific and economic competition with other nations. At the present moment I believe there is nothing more important than to supply the deficiencies which separate us from those with whom we are in the closest competition. In Germany, in America, in our own colony of Canada and in Australia, the higher education of the people has more support from the Government, is carried further, than it is here in the Old Country; and the result is that in every profession, in every industry, you find the places taken by men and by women who have had a university education. And I would like to see the time in this country when no man should have a chance for any occupation of the better kind, either in our factories, our workshops or our counting-houses, who could not show proof that in the course of his university career he

had deserved the position that was offered to him. What is it that makes a country? Of course you may say, and you would be quite right, "The general qualities of the people, their resolution, their intelligence, their pertinacity and many other good qualities." Yes; but that is not all, and it is not the main creative feature of a great nation. The greatness of a nation is made by its greatest men. It is those we want to educate. It is to those who are able to go, it may be, from the very lowest steps in the ladder, to men who are able to devote their time to higher education, that we have to look to continue the position which we now occupy as at all events one of the greatest nations on the face of the earth. And, feeling as I do on these subjects, you will not be surprised if I say that I think the time is coming when Governments will give more attention to this matter, and perhaps find a little more money to forward its interests.*

Our conception of a University has changed. University education is no longer regarded as the luxury of the rich, which concerns only those who can afford to pay heavily for it. The Prime Minister in a recent speech, while properly pointing out that the collective effect of our public and secondary schools upon British character cannot be overrated, frankly acknowledged that the boys of seventeen or eighteen who have to be educated in them "do not care a farthing about the world they live in except in so far as it concerns the cricket-field or the football-field or the river." On this ground they are not to be taught science; and hence, when they proceed to the University, their curriculum is limited to subjects which were better taught before the modern world existed, or even Galileo was born. But the science which these young gentlemen neglect, with the full approval of their teachers, on their way through the school and the University to politics, the Civil Service or the management of commercial concerns, is now one of the great necessities of a nation; and our Universities must become as much

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* *The Times*, November 6, 1902.

the insurers of the future progress as battleships are the insurers of the present power of States. In other words, University competition between States is now as potent as competition in building battleships; and it is on this ground that our University conditions become of the highest national concern, and therefore have to be referred to here, and all the more because our industries are not alone in question.

Why we have not more Universities.

Chief among the causes which have brought us to the terrible condition of inferiority as compared with other nations in which we find ourselves are our carelessness in the matter of education and our false notions of the limitations of State functions in relation to the conditions of modern civilisation.

Time was when the Navy was largely a matter of private and local effort. William the Conqueror gave privileges to the Cinque Ports on the condition that they furnished fifty-two ships when wanted. In the time of Edward III., of 730 sail engaged in the siege of Calais 705 were "people's ships." All this has passed away; for our first line of defence we no longer depend on private and local effort.

Time was when not a penny was spent by the State on elementary education. Again, we no longer depend upon private and local effort. The Navy and primary education are now recoginsed as properly calling upon the public for the necessary financial support. But when we pass from primary to University education, instead of State endowment we find State neglect; we are in a region where it is nobody's business to see that anything is done.

We in Great Britain have thirteen Universities competing with 134 State and privately endowed in the United States and twenty-two State endowed in Germany. I leave other countries out of consideration for lack of time, and I omit all reference to higher institutions for technical training, of which Germany alone possesses nine of University rank, because they are less important; they instruct rather than educate, and our want is education. The German State gives to one University more than the British Government allows to all the Universities and University Colleges in England, Ireland, Scotland and Wales put together. These are the conditions which regulate the production of brain-power in the United States, Germany and Britain respectively, and the excuse of the Government is that this is a matter for private effort. Do not our Ministers of State know that other civilised countries grant efficient State aid, and, further, that private effort has provided in Great Britain less than 10 per cent. of the sum thus furnished in the United States in addition to State aid? Are they content that we should go under in the great struggle of the modern world because the Ministries of other States are wiser, and because the individual citizens of another country are more generous, than our own?

If we grant that there was some excuse for the State's neglect so long as the higher teaching dealt only with words, and books alone had to be provided (for the streets of London and Paris have been used as class-rooms at a pinch), it must not be forgotten that during the last hundred years not only has knowledge been enormously increased, but things have replaced words, and fully equipped laboratories must take the place of books and

class-rooms if University training worthy of the name is to be provided. There is much more difference in size and kind between an old and a new University than there is between the old caravel and a modern battleship, and the endowments must follow suit.

What are the facts relating to private endowment in this country ? In spite of the munificence displayed by a small number of individuals in some localities, the truth must be spoken. In depending in our country upon this form of endowment we are trusting to a broken reed. If we take the twelve English University Colleges, the forerunners of Universities unless we are to perish from lack of knowledge, we find that private effort during sixty years has found less than £4,000,000 ; that is, £2,000,000 for buildings, and £40,000 a year income. This gives us an average of £166,000 for buildings, and £3,300 for yearly income.

What is the scale of private effort we have to compete with in regard to the American Universities ?

In the United States, during the last few years, Universities and colleges have received more than £40,000,000 from this source alone ; private effort supplied nearly £7,000,000 in the years 1898–1900.

Next consider the amount of State aid to Universities afforded in Germany. The buildings of the new University of Strassburg have already cost nearly £1,000,000 ; that is, about as much as has yet been found by private effort for buildings in Manchester, Liverpool, Birmingham, Bristol, Newcastle and Sheffield. The Government annual endowment of the same German University is more than £49,000.

This is what private endowment does for us in England, against State endowment in Germany.

But the State does really concede the principle; its present contribution to our Universities and colleges amounts to £155,600 a year. No capital sum, however, is taken for buildings. The State endowment of the University of Berlin in 1891–1892 amounted to £168,777.

When, then, we consider the large endowments of University education both in the United States and Germany, it is obvious that State aid only can make any valid competition possible with either. The more we study the facts, the more statistics are gone into, the more do we find that we, to a large extent, lack both of the sources of endowment upon one or other, or both, of which other nations depend. We are between two stools, and the prospect is hopeless without some drastic changes. And first among these, if we intend to get out of the present Slough of Despond, must be the giving up of the idea of relying upon private effort.

That we lose most where the State does least is known to Mr. Chamberlain, for in his speech, to which I have referred, on the University of Birmingham, he said:—

> "As the importance of the aim we are pursuing becomes more and more impressed upon the minds of the people, we may find that we shall be more generously treated by the State."

Later still, on the occasion of a visit to University College School, Mr. Chamberlain spoke as follows:—

> "When we are spending, as we are, many millions—I think it is 13,000,000*l.*—a year on primary education, it certainly seems as if we might add a little more, even a few tens of thousands, to what we give to university and secondary education."*

To compete on equal grounds with other nations we must have more Universities. But this is not all—we

* *The Times*, November 6, 1902.

want a far better endowment of all the existing ones, not forgetting better opportunities for research on the part of both professors and students. Another crying need is that of more professors and better pay. Another is the reduction of fees; they should be reduced to the level existing in those countries which are competing with us—to, say, one-fifth of their present rates, so as to enable more students in the secondary and technical schools to complete their education.

In all these ways facilities would be afforded for providing the highest instruction to a much greater number of students. At present there are almost as many *professors and instructors* in the Universities and colleges of the United States as there are *day students* in the Universities and colleges of the United Kingdom.

Men of science, our leaders of industry and the chiefs of our political parties all agree that our present want of higher education—in other words, properly equipped Universities—is heavily handicapping us in the present race for commercial supremacy, because it provides a relatively inferior brain-power, which is leading to a relatively reduced national income.

The facts show that in this country we cannot depend upon private effort to put matters right. How about local effort?

Anyone who studies the statistics of modern municipalities will see that it is impossible for them to raise rates for the building and upkeep of Universities.

The buildings of the most modern University in Germany have cost £1,000,000. For upkeep the yearly sums found, chiefly by the State, for German Universities of

different grades, taking the incomes of seven out of the twenty-two Universities as examples, are :—

		£
First Class	Berlin	130,000
Second Class	Bonn, Göttingen	56,000
Third Class	Konigsberg, Strassburg	48,000
Fourth Class	Heidelberg, Marburg	37,000

Thus, if Leeds, which is to have a University, is content with the fourth class German standard, a rate must be levied of 7d. in the £ for yearly expenses, independent of all buildings. But the facts are that our towns are already at the breaking strain. During the last fifty years, in spite of enormous increases in rateable values, the rates have gone up from about 2s. to about 7s. in the £ for real *local* purposes. But no University can be a merely local institution.

How to get more Universities.

What, then, is to be done ? Fortunately, we have a precedent admirably in point, the consideration of which may help us to answer this question.

I have pointed out that in old days our Navy was chiefly provided by local and private effort. Fortunately for us those days have passed away ; but some twenty years ago, in spite of a large expenditure, it began to be felt by those who knew, that in consequence of the increase of foreign navies our sea-power was threatened, as now, in consequence of the increase of foreign Universities, our brain-power is threatened.

The nation slowly woke up to find that its enormous commerce was no longer insured at sea, that in relation

to foreign navies our own had been suffered to dwindle to such an extent that it was no longer capable of doing the duty which the nation expected of it even in times of peace. At first this revelation was received with a shrug of incredulity, and the peace-at-any-price party denied that anything was needed; but a great teacher arose;* as the facts were inquired into, the suspicion changed into an alarm; men of all parties saw that something must be done. Later the nation was thoroughly aroused, and with an universal agreement the principle was laid down that, cost what it might to enforce our sea-power, our Navy must be made and maintained of a strength greater than those of any two possibly contending Powers. After establishing this principle, the next thing to do was to give effect to it. What did the nation do after full discussion and inquiry? A Bill was brought in in 1888, and a sum of £21,500,000 was voted in order, during the next five years, to inaugurate a large ship-building programme, so that Britain and Britain's commerce might be guarded on the high seas in any event.

Since then we have spent £120,000,000 on new ships, and this year we spend still more millions on still more new ships. If these prove insufficient to safeguard our sea-power, there is no doubt that the nation will increase them, and I have not heard that anybody has suggested an appeal to private effort.

How, then, do we stand with regard to Universities, recognising them as the chief producers of brain-power and therefore the equivalents of battleships in relation to sea-power? Do their numbers come up to the standard

* Captain Mahan, of the U.S. Navy, whose book, "On the Influence of Sea-power on History," has suggested the title of my address.

established by the Admiralty principle to which I have referred? Let us attempt to get a rough-and-ready estimate of our educational position by counting Universities as the Admiralty counts battleships. I say rough-and-ready, because we have other helps to greater brain power to consider besides Universities, as the Admiralty has other ships to consider besides ironclads.

In the first place, let us inquire if they are equal in number to those of any two nations commercially competing with us.

In the United Kingdom we had until quite recently thirteen.* Of these, one is only three years old as a teaching University, and another is still merely an examining board.

In Germany there are twenty-two Universities; in France, under recent legislation, fifteen; in Italy, twenty-one. It is difficult to give the number in the United States, because it is clear, from the tables given in the Report of the Commissioner of Education, that some colleges are more important than some Universities, and both give the degree of Ph.D. But of Universities in title we have 134. Among these, there are forty-six each with more than fifty professors and instructors, and thirteen of these with more than 150. I will take that figure.

Suppose we consider the United States and Germany, our chief commercial competitors, and apply the Admiralty principle. We should require, allowing for population, eight additional Universities at the very lowest estimate.

We see, then, that instead of having Universities

* These are Oxford, Cambridge, Durham, Victoria, Wales, Birmingham, London, St. Andrews, Glasgow, Aberdeen, Edinburgh, Dublin and Royal University.

equalling in number those of two of our chief competitors together, they are by no means equal to those of either of them singly.

After this statement of the facts, anyone who has belief in the importance of higher education will have no difficulty in understanding the origin of the present condition of British industry and its constant decline, first in one direction and then in another, since the tremendous efforts made in the United States and Germany began to take effect.

If, indeed, there be anything wrong about the comparison, the error can only arise from one of two sources—either the Admiralty is thoughtlessly and wastefully spending money, or there is no connection whatever between the higher intelligence and the prosperity of a nation. I have already referred to the views of Mr. Chamberlain and Lord Rosebery on this point; we know what Mr. Chamberlain has done at Birmingham; we know the strenuous efforts made by the commercial leaders of Manchester and Liverpool; we know, also, the opinion of men of science.

If while we spend so freely to maintain our sea-power our export of manufactured articles is relatively reduced because our competitors beat us in the markets of the world, what is the end of the vista thus opened up to us? A Navy growing stronger every year and requiring larger votes to guard our commerce and communications, and a vanishing quantity of commerce to guard—a reduced national income to meet an increasing taxation!

The pity is that our Government has considered sea-power alone; that while so completely guarding our commerce it has given no thought to one of the main con-

ditions on which its production and increase depend. A glance could have shown that other countries were building Universities even faster than they were building battleships; were, in fact, considering brain-power first and sea-power afterwards.

Surely it is my duty as your President to point out the danger ahead, if such ignoring of the true situation should be allowed to continue. May I express a hope that at last, in Mr. Chamberlain's words, "The time is coming when Governments will give more attention to this matter"?

What will they cost?

The comparison shows that we want eight new Universities, some of which, of course, will be colleges promoted to University rank and fitted to carry on University work Three of them are already named: Manchester, Liverpool, Leeds.

Let us take this number and deal with it on the battleship condition, although a modern University on American or German models will cost more to build than a battleship.

If our present University shortage be dealt with on battleship conditions, to correct it we should expend *at least* £8,000,000 for new construction, and for the pay-sheet we should have to provide (8 × £50,000) £400,000 yearly for *personnel* and up-keep; for it is of no use to build either ships or Universities without manning them. Let us say, roughly, capitalising the yearly payment at 2½ per cent., £24,000,000.

At this stage it is important to inquire whether this sum, arrived at by analogy merely, has any relation to our real University needs.

I have spent a year in making inquiries, as full as I could make them, of friends conversant with the real present needs of each of the Universities, old and new. I have obtained statistics which would fill a volume, and personally I believe that this sum at least is required to bring our University system up to anything like the level which is insisted upon both in the United States and in Germany. Even Oxford, our oldest University, will still continue to be a mere bundle of colleges unless £3,000,000 are provided to enable the University, properly so called, to take her place among her sisters of the modern world; and Sir Oliver Lodge, the Principal of our very youngest University, Birmingham, has shown in detail how £5,000,000 can be usefully and properly applied in that one locality to utilise for the good of the nation the enthusiasm and scientific capacity which are only waiting for adequate opportunity of development.

How is this money to be raised? I reply, without hesitation, *Duplicate the Navy Bill of* 1888–1889; do at once for brain-power what we so successfully did then for sea-power.

Let £24,000,000 be set apart from one asset, our national wealth, to increase the other, brain-power. Let it be assigned and borrowed as it is wanted; there will be a capital sum for new buildings to be erected in the next five or ten years, the interest of the remainder to go towards increased annual endowments.

There need be no difficulty about allocating money to the various institutions. Let each University make up its mind as to which rank of the German Universities it wishes to emulate. When this claim has been agreed to, the sums necessary to provide the buildings

and teaching staff of that class of University should be granted without demur.

It is the case of battleships over again, and money need not be spent more freely in one case than in the other.

Let me at once say that this sum is not to be regarded as practically gone when spent, as in the case of a short-lived ironclad. *It is a loan* which will bear a high rate of interest. This is not my opinion merely ; it is the opinion of those concerned in great industrial enterprises and fully alive to the origin and effects of the present condition of things.

I have been careful to point out that the statement that our industries are suffering from our relative neglect of science does not rest on my authority. But if this be true, then if our annual production is less by only £2,000,000 than it might have been, having £2,000,000 less to divide would be equivalent to our having £40,000,000 or £50,000,000 less capital than we should have had if we had been more scientific.

Sir John Brunner, in a speech connected with the Liverpool School of Tropical Medicine, stated recently that if we as a nation were now to borrow £10,000,000 in order to help science by putting up buildings and endowing professors, we should get the money back in the course of a generation a hundredfold. He added that there was no better investment for a business man than the encouragement of science, and that every penny he possessed had come from the application of science to commerce.

According to Sir Robert Giffen, the United Kingdom as a going concern was in 1901 worth £16,000,000,000.

Were we to put aside £24,000,000 for gradually organising, building, and endowing new Universities, and making

the existing ones more efficient we should still be worth £15,976,000,000—a property well worth defending by all the means, and chief among these brain-power, we can command.

If it be held that this, or anything like it, is too great a price to pay for correcting past carelessness or stupidity, the reply is that the £120,000,000 recently spent on the Navy, a sum five times greater, has been spent to correct a sleepy blunder, not one whit more inimical to the future welfare of our country than that which has brought about our present educational position. We had not sufficiently recognised what other nations had done in the way of ship-building, just as until now we have not recognised what they have been doing in University building.

Further, I am told that the sum of £24,000,000 is less than half the amount by which Germany is yearly enriched by having improved upon our chemical industries, owing to our lack of scientific training. Many other industries have been attacked in the same way since; but taking this one instance alone, if we had spent this money fifty years ago, when the Prince Consort first called attention to our backwardness, the nation would now be much richer than it is, and would have much less to fear from competition.

Suppose we were to set about putting our educational house in order, so as to secure a higher quality and greater quantity of brain-power, it would not be the first time in history that this has been done. Both Prussia after Jena and France after Sedan acted on the view:—

"When land is gone and money spent,
Then learning is most excellent."

After Jena, which left Prussia a "bleeding and lacerated mass," the King and his wise counsellors, among them men who had gained knowledge from Kant, determined, as they put it, 'to supply the loss of territory by intellectual effort."

What did they do? In spite of universal poverty, three Universities, to say nothing of observatories and other institutions, were at once founded, secondary education was developed, and in a few years the mental resources were so well looked after that Lord Palmerston defined the kingdom in question as "a country of damned professors."

After Sedan—a battle, as Moltke told us, "won by the schoolmaster"—France made even more strenuous efforts. The old University of France, with its "academies" in various places, was replaced by fifteen independent Universities, in all of which are faculties of letters, sciences, law and medicine.

The development of the University of Paris has been truly marvellous. In 1897–8 there were 12,000 students, and the cost was £200,000 a year.

But even more wonderful than these examples is the "intellectual effort" made by Japan, not after a war, but to prepare for one.

The question is, Shall we wait for a disaster and then imitate Prussia and France; or shall we follow Japan and thoroughly prepare by "intellectual effort" for the industrial struggle which lies before us?

Such an effort seems to me to be the first thing any national or imperial scientific organisation should endeavour to bring about.

Research.

When dealing with our Universities I referred to the importance of research, as it is now generally acknowledged to be the most powerful engine of education that we possess. But education, after all, is but a means to the end, which, from the national point of view, is the application of old and the production of new knowledge. Its national importance apart from education is now so generally recognised that in all civilised nations except our own means of research are being daily more amply provided for all students after they have passed through their University career; and, more than this, for all who can increase the country's renown or prosperity by the making of new knowledge, upon which not only commercial progress, but all intellectual advance must depend.

I am so anxious that my statement of our pressing, and indeed imperative, needs in this direction should not be considered as resting upon the possibly interested opinion of a student of science merely that I must trouble you with still more quotations.

Listen to Mr. Balfour:—

"I do not believe that any man who looks round the equipment of our universities or medical schools or other places of education can honestly say in his heart that we have done enough to equip research with all the costly armoury which research must have in these modern days. We, the richest country in the world, lag behind Germany, France, Switzerland and Italy. Is it not disgraceful? Are we too poor or are we too stupid?"*

It is imagined by many who have given no thought to the matter that this research should be closely allied with some application of science being utilised at the

* *Nature*, May 30, 1901.

time. Nothing could be further from the truth; nothing could be more unwise than such a limitation.

Surely all the laws of Nature will be ultimately of service, and therefore there is much more future help to be got from a study of the unknown and the unused than we can hope to obtain by continuing the study of that which is pretty well known and utilised already. It was a King of France, Louis XIV., who first commended the study of the *même inutile*. The history of modern science shows us more and more as the years roll on the necessity and advantage of such studies, and therefore the importance of properly endowing them; for the production of new knowledge is a costly and unremunerative pursuit.

Years ago we had Faraday apparently wasting his energies and time in playing with needles; electricity now fills the world. To-day men of science in all lands are studying the emanations of radium; no research could be more abstract; but who knows what advance in human thought may follow or what gigantic world-transforming superstructure may eventually be raised on the minute foundation they are laying?

If we so organise our teaching forces that we can use them at all stages, from the gutter to the University, to sift out for us potential Faradays—to utilise the mental products which otherwise would be wasted—it is only by enabling such men to continue their learning after their teaching is over that we shall be able to secure the greatest advantage which any educational system can afford.

It is now more than thirty years ago that my attention was specially drawn to this question of the endowment of research—first, by conversations with M. Dumas, the

permanent secretary of the Academy of Sciences, who honoured me by his friendship; and, secondly, by my association with Sir Benjamin Brodie and Dr. Appleton in their endeavours to call attention to the matter in this country. At that time a general scheme of endowment suggested by Dumas was being carried out by Duruy. This took the form of the "École spéciale des Hautes Études"; it was what our fellowship system was meant to be—an endowment of the research of post-graduate students in each seat of learning. The French effort did not begin then.

I may here tell, as it was told me by Dumas, the story of Léon Foucault, whose many discoveries shed a glory on France and revived French industry in many directions.* In 1851, when Prince Napoleon was President of the Republic, he sent for Dumas and some of his colleagues, and told them that during his stay in England, and afterwards in his study of the Great Exhibition of that year, he had found there a greater industrial development than in France, and more applications of science, adding that he wished to know how such a state of things could be at once remedied. The answer was that new applications depended upon new knowledge, and that therefore the most direct and immediate way was to find and encourage men who were likely by research in pure science to produce this new knowledge. The Prince-President at once asked for names; that of Léon Foucault was the only one mentioned during the first interview.

Some time afterwards—to be exact, at about eleven in the morning of December 2nd—Dumas's servant informed him that there was a gentleman in the hall named

* See *Proc. R. S.* vol. xvii. p. lxxxiii.

Foucault, who wished to see him, and he added that he appeared to be very ill. When shown into the study, Foucault was too agitated to speak, and was blind with tears. His reply to Dumas's soothing questions was to take from his pockets two rolls of banknotes, amounting to 200,000 francs, and place them on the table. Finally, he was able to say that he had been with the Prince-President since eight o'clock that morning, discussing the possible improvement of French science and industry; and that Napoleon had finally given him the money, requesting him to do all in his power to aid the State. Foucault ended by saying that, on realising the greatness of the task thus imposed upon him, his fears and feelings had got the better of him, for the responsibility seemed more than he could bear.*

The movement in England to which I have referred began in 1872, when a society for the organisation of academical study was formed in connection with the inquiry into the revenues of Oxford and Cambridge, and there was a famous meeting at the Freemasons' Tavern, Mark Pattison being in the chair. Brodie, Rolleston, Carpenter, Burdon-Sanderson were among the speakers, and the first resolution carried was, "That to have a class of men whose lives are devoted to research is a national object." The movement died in consequence of the want of sympathy of the University authorities.†

In the year 1874 the subject was inquired into by the

* In order to show how history is written, what actually happened on a fateful morning may be compared with the account given by Kinglake: "Prince Louis rode home and went in out of sight. Then for the most part he remained close shut up in the Elysée. There, in an inner room, still decked in red trousers, but with his back to the daylight, they say he sat bent over a fireplace for hours and hours together resting his elbows on his knees, and burying his face in his hands."—*Crimean War*, vol. i. p. 245.

† See *Nature*, November and December, 1872.

late Duke of Devonshire's Commission; and after taking much remarkable evidence, including that of Lord Salisbury, the Commission recommended to the Government that the then grant of £1,000, which was expended, by a committee appointed by the Royal Society, on instruments needed in researches carried on by private individuals, should be increased, so that personal grants should be made. This recommendation was accepted and acted on; the grant was increased to £4,000, and finally other societies were associated with the Royal Society in its administration. The committee, however, was timorous, possibly owing to the apathy of the Universities and the general carelessness on such matters, and only one personal grant was made; the whole conception fell through.

Meantime, however, opinion has become more educated and alive to the extreme importance of research to the nation, and in 1891 a suggestion was made to the Royal Commission which administers the proceeds of the 1851 Exhibition that a sum of about £6,000 a year available for scholarships should be employed in encouraging post-graduate research throughout the whole Empire. As what happened is told in the Memoirs of Lord Playfair, it is not indiscreet in me to state that when I proposed this new form of the endowment of research it would not have surprised me if the suggestion had been declined. It was carried through by Lord Playfair's enthusiastic support. This system has been at work ever since, and the good that has been done by it is now generally conceded.

It is a supreme satisfaction to me to know that in this present year of grace the national importance of the study of the *même inutile* is more generally recognised than it was

during the times to which I have referred in my brief survey; and, indeed, we students are fortunate in having on our side in this matter two members of His Majesty's Government, who two years ago spoke with no uncertain sound upon this matter:—

"Do we lack the imagination required to show what these apparently remote and abstract studies do for the happiness of mankind? We can appreciate that which obviously and directly ministers to human advancement and felicity, but seem, somehow or another, to be deficient in that higher form of imagination, in that longer sight, which sees in studies which have no obvious, necessary or immediate result the foundation of the knowledge which shall give far greater happiness to mankind than any immediate, material, industrial advancement can possibly do; and I fear, and greatly fear, that, lacking that imagination, we have allowed ourselves to lag in the glorious race run now by civilised countries in pursuit of knowledge, and we have permitted ourselves so far to too large an extent to depend upon others for those additions to our knowledge which surely we might have made for ourselves."*

"I would remind you that all history shows that progress—national progress of every kind—depends upon certain individuals rather than upon the mass. Whether you take religion, or literature, or political government, or art, or commerce, the new ideas, the great steps, have been made by individuals of superior quality and genius, who have, as it were, dragged the mass of the nation up one step to a higher level. So it must be in regard to material progress. The position of the nation to-day is due to the efforts of men like Watt and Arkwright, or, in our own time, to the Armstrongs, the Whitworths, the Kelvins and the Siemenses. These are the men, who, by their discoveries, by their remarkable genius, have produced the ideas upon which others have acted and which have permeated the whole mass of the nation and affected the whole of its proceedings. Therefore what we have to do, and this is our special task and object, is to produce more of these great men."†

I finally come to the political importance of research. A country's research is as important in the long run as its battleships. The most eloquent teaching as to its national

* Mr. Balfour, *Nature*, May 30, 1901.

† Mr. Chamberlain *The Times*, January 18, 1901.

value we owe to Mr. Carnegie, for he has given the sum of £2,000,000 to found a system of endowments, his chief purpose being, in his own words, "to secure if possible for the United States of America leadership in the domain of discovery and the utilisation of new forces for the benefit of man."

Here is a distinct challenge to Britain. Judging by experience in this country, in spite of the magnificent endowment of research by Mond and Lord Iveagh, the only source of possible competition in the British interest is the State, which certainly could not put the 1/8,000th part of the accumulated wealth of the country to better use; for without such help both our Universities and our battleships will become of rapidly dwindling importance.

It is on this ground that I have included the importance of endowing research among the chief points to which I have been anxious to draw your attention.

The Need of a Scientific National Council.

In referring to the new struggle for existence among civilised communities I pointed out that the solution of a large number of scientific problems is now daily required for the State service, and that in this and other ways the source and standard of national efficiency have been greatly changed.

Much evidence bearing upon the amount of scientific knowledge required for the proper administration of the public departments, and the amount of scientific work done by and for the nation, was brought before the Royal Commission on Science presided over by the late Duke of Devonshire now more than a quarter of a century ago.

The Commission unanimously recommended that the

State should be aided by a scientific council in facing the new problems constantly arising.

But while the home Government has apparently made up its mind to neglect the advice so seriously given, it should be a source of gratification to us all to know that the application of the resources of modern science to the economic, industrial and agricultural development of India has for many years engaged the earnest attention of the Government of that country. The Famine Commissioners of 1878 laid much stress on the institution of scientific inquiry and experiment designed to lead to the gradual increase of the food-supply and to the greater stability of agricultural outturn, while the experience of recent years has indicated the increasing importance of the study of the economic products and mineral-bearing tracts.

Lord Curzon has recently ordered the heads of the various scientific departments to form a board, which shall meet twice annually, to begin with, to formulate a programme and to review past work. The board is also to act as an advisory committee to the Government,* providing among other matters for the proper co-ordination of all matters of scientific inquiry affecting India's welfare.

Lord Curzon is to be warmly congratulated upon the step he has taken, which is certain to bring benefit to our great Dependency.

The importance of such a board is many times greater at home, with so many external as well as internal interests to look after—problems common to peace and war, problem requiring the help of the economic as well as of the physical sciences.

* *Nature*, September 4, 1902.

It may be asked, What is done in Germany, where science is fostered and utilised far more than here?

The answer is, There is such a council. I fancy, very much like what our Privy Council once was. It consists of representatives of the Ministry, the universities, the industries and agriculture. It is small, consisting of about a dozen members, consultative, and it reports direct to the Emperor. It does for industrial war what military and so-called defence councils do for national armaments; it considers everything relating to the use of brain-power in peace—from alterations in school regulations and the organisation of the universities, to railway rates and fiscal schemes, including the adjustment of duties. I am informed that what this council advises, generally becomes law.

It should be pretty obvious that a nation so provided must have enormous chances in its favour. It is a question of drilled battalions against an undisciplined army, of the use of the scientific spirit as opposed to the hope of "muddling through."

Mr. Haldane has recently reminded us that "the weapons which science places in the hands of those who engage in great rivalries of commerce leave those who are without them, however brave, as badly off as were the dervishes of Omdurman against the Maxims of Lord Kitchener."

Without such a machinery as this, how can our Ministers and our rulers be kept completely informed on a thousand things of vital importance? Why should our position and requirements as an industrial and thinking nation receive less attention from the authorities than the head-dress of the Guards? How, in the words of Lord Curzon,*

* *The Times*, September 30, 1902.

can "the life and vigour of a nation be summed up before the world in the person of its sovereign" if the national organisation is so defective that it has no means of keeping the head of the State informed on things touching the most vital and lasting interests of the country? We seem to be still in the Palæolithic Age in such matters, the chief difference being that the sword has replaced the flint implement.

Some may say that it is contrary to our habit to expect the Government to interest itself too much or to spend money on matters relating to peace; that war dangers are the only ones to be met or to be studied.

But this view leaves science and the progress of science out of the question. Every scientific advance is now, and will in the future be more and more, applied to war. It is no longer a question of an armed force with scientific corps; it is a question of an armed force scientific from top to bottom. Thank God the Navy has already found this out. Science will ultimately rule all the operations both of peace and war, and therefore the industrial and the fighting population must both have a large common ground of education. Already it is not looking too far ahead to see that in a perfect State there will be a double use of each citizen—a peace use and a war use; and the more science advances, the more the old difference between the peaceful citizen and the man at arms will disappear. The barrack, if it still exists, and the workshop will be assimilated; the land unit, like the battleship, will become a school of applied science, self-contained, in which the officers will be the efficient teachers.

I do not think it is yet recognised how much the problem

of national defence has thus become associated with that with which we are now chiefly concerned.

These, then, are some of the reasons which compel me to point out that a scientific council, which might be a scientific committee of the Privy Council, in dealing primarily with the national needs in times of peace, would be a source of strength to the nation.

To sum up, then. My earnest appeal to you is to gird up your loins and see to it that the science of the British Empire shall no longer remain unorganised. I have endeavoured to point out to you how the nation at present suffers from the absence of a powerful, continuous, reasoned expression of scientific opinion, urging in season and out of season that we shall be armed, as other nations are, with efficient universities and facilities for research to uphold the flag of Britain in the domain of learning and discovery, and what they alone can bring.

I have also endeavoured to show how, when this is done, the nation will still be less strong than it need be if there be not added to our many existing councils another, to secure that even during peace the benefits which a proper co-ordination of scientific effort in the nation's interest can bring shall not be neglected as they are at present.

Lest some of you may think that the scientific organisation which I trust you will determine to found would risk success in working on such large lines, let me remind you that in 1859, when the late Prince Consort occupied this Chair, he referred to "impediments" to scientific progress, and said, "they are often such as can only be successfully dealt with by the powerful arm of the State or the long purse of the nation."

If the Prince Consort had lived to continue his advocacy of science, our position to-day would bave been very different. His early death was as bad for Britain as the loss of a great campaign. If we cannot make up what we have lost, matters cannot mend.

I have done what I feel to be my duty in bringing the present condition of things before you. It is now your duty, if you agree with me, to see that it be put right. You can if you will.

THE NATIONAL NEED OF THE STATE ENDOWMENT OF UNIVERSITIES.*

(1904.)

(1) The British Association has taken action regarding the State endowment of universities, because at the present juncture the highest education and research is a matter not merely of academic but of the gravest national concern.

There is now a general opinion that Britain is in danger of falling behind in the industrial competition now going on between the most highly civilised States.

The university no less than the primary school is in question, because we are in the midst of a struggle in which science and brains take the place of swords and sinews; the school, the university, the laboratory and the workshop are the battlefields of this new struggle, and the scientific spirit must not be limited to the workshop, since other nations utilise it in all branches of their administration and executive.

The more our legislators, administrators and executive officers possess the scientific spirit, and the more the rule of thumb is replaced by scientific methods, the

* Statement prepared by the author as President of the British Association and revised by a committee consisting of the Deputy Vice-Chancellor of Oxford, the Vice-Chancellor of the University of Cambridge, Sir Oliver Lodge, Principal of the University of Birmingham, Sir Michael Foster, M.P., and Sir Henry Roscoe.

more able shall we be to compete successfully with other countries along all lines of national as well as of commercial activity.

It is a question of an important change of front, of finding a new basis of stability for the Empire in face of new conditions; and since the full life of a nation with a constantly increasing complexity, not only industrial but of high national aims, depends upon the universal presence of the scientific spirit, of brain-power, our whole national life is involved.

The Function of a University in a Modern State.

The men upon whom the nation must chiefly depend for aid under the complex conditions of the modern world must not be entirely untrained in the study of the nature and causes of the things which surround them, or of the forces which have to be utilised in our daily life; their training and education in humanities must also have been of the widest.

Such men cannot be produced either by a university which neglects science or by a technical college which neglects the humanities.

Hence the universities must be enabled to combine these two sides of a complete education, and they must also be enabled to foster research along both lines, for research is the highest and most important instrument of education, as well as its most valuable result. When science and its applications were of less importance than now the humanities sufficed and university requirements were small; rooms, books and a small number of teachers of a small number of subjects comprised the essentials of the university. Modern

university needs have been too much regarded from this old standpoint.

All this is now changed. For instance, in the most modern German university the buildings, all elaborate and all differing from each other, have already cost a million, and still the university is not complete. Books have to be supplemented by expensive instrumental equipments, which constantly have to be added to or replaced, and by utilising this new material the fruitful ramifications of learning have increased fifty-fold, and the teachers naturally in even greater proportion.

The extraordinary thing is not that a claim to meet these new conditions is made now, but that we have waited so long for it in this country while other countries faced them long ago.

The Money.

Money is required at the present moment for:—

(1) Buildings and equipments for pure and applied science in both old and new universities.

(2) Pay and pensions of an increased number of professors, demonstrators, etc., in pure and applied science in both old and new universities.

(3) Strengthening of science teaching and research in all, and of the humanities in the new universities.

(4) Reduction of fees, and the wide educational enfranchisement of proved ability in all classes.

Hitherto universities have looked mainly to private endowments. Universities have been regarded too much as luxuries of the rich, and perhaps on this ground higher education has been treated by the Government

as of trivial importance to the nation, as a thing it may properly disregard.

Judging from the action taken in other countries it is safe to say that private endowment has not produced more than 10 per cent. of the money actually needed in Britain.

Nor can we rightly appeal to local rate-aid alone. It would be unjust to expect certain restricted localities to provide universities which, if we are to go on, must be utilised by the whole Empire.

We are driven then to the State. The other civilised States largely endow their universities; Germany, with an aggregate income less than ours, spends roughly £1,000,000 a year on its universities. The University of Berlin alone received more than £168,000 from the State in the year 1891–2. In the United States, in addition to £200,000 a year received from the Government, the States supply £700,000 in the aggregate and private endowment £2,000,000. The University of Tokio receives £130,000 a year from the Government of Japan.

These figures derive their chief importance from the fact that these magnificently endowed and State-aided universities are the institutions we are contending with in the production of men to do the nation's work along all the lines of its activities.

But the large sums available for the efficient working of the German and American universities are not alone in question. The number of universities in Germany is nearly double that of the British universities. The number of first-class universities in the United States where, as Mr. Choate has told us, education is the chief business of the nation, is nearly four times that of the British universities.

Can we Afford to Spend Money on Universities?

Britain's great needs at the present moment are brain-power to invigorate our commerce, among other things, and sea-power to guard it, among other things. The State has recently spent £120,000,000 to bring our Navy up to date; it has not yet spent a single million on our universities.

Sir Robert Giffen has stated that the yearly income of the people of the United Kingdom may be taken as not less than 1650 millions, and their aggregate expenditure a few years ago was not less than £1,400,000,000., including £30,000,000 for education, which is less than 2 per cent of the whole. The amount borne on the estimates for education is about £13,000,000.

He writes:—

> "The country should be spending 100 millions, where it now spends thirty, or about 5 per cent. . . . Such sums are not really extravagant. Extensive diffusion of education and scientific knowledge and training are not only essential to the greater efficiency of labour and capital by which the means of living are provided, but they are equally needed for the conduct of life itself, for the health and comfort of the workers."

It cannot be doubted that the expenditure will be quickly remunerative. More efficient workers will produce more.

Money so spent is seed from which a harvest can be looked for; the plentifulness of the crop will depend upon the seed and the way it is sown.

One of our manufacturers who has been most successful in applying science to industry has stated that if we were now to borrow £10,000,000 for university purposes we should get the money back in the course of one generation a hundred-fold.

The recent recognition of the fact that we have too few universities, and that those that we have are inefficient for want of funds, is similar to that awakening which occurred in 1888 regarding the Navy. In both cases we have to correct past mistakes lasting for years, and seeing that university buildings, as well as annual endowments, are required, some special provision should be made for their early erection.

The Universities in Relation to Secondary Education.

Now that the primary and secondary schools throughout the country are being co-ordinated, the time has arrived for making our universities and university colleges efficient. The teaching connected with the universities must be of the highest, and the chief function of the secondary schools should be to produce students possessing that general training in science and the humanities which will ensure the success of their subsequent careers, either inside or outside a university.

A system of leaving certificates and a reduction of fees would at once get rid of the tyranny of merely qualifying or selecting examinations which are the bane of education, and would enable the training of the poorest to be carried to the highest rung of an unbroken ladder.

OPENING ADDRESS AT THE INAUGURATION OF THE BRITISH SCIENCE GUILD.*

(1905.)

My Lord Mayor, Ladies and Gentlemen,—My duty is to present a very brief report of the action of the organising committee of the Guild, which has led up to the present meeting. The Royal Society permitted the first meeting of the committee to be held in its rooms, in June of last year; officers were appointed and a Memorandum was drawn up, sketching the objects and proposed organisation of the guild, for circulation among those whose sympathy and support were hoped for. The Memorandum was circulated privately in the first instance. The responses received were so extremely satisfactory, that the committee felt justified in their belief that a large number of the most distinguished representatives of every branch of national life and activity were in sympathy with the movement, and eventually the Memorandum was circulated to the members of both Houses of Parliament and the Fellows of the Royal Society, and afterwards to various technical societies, chambers of commerce and similar organisations. Notices were also sent to the Press. At a meeting held in last March, it was resolved to advance beyond the general statement of objects, which was all the organising committee was in a position

* At the Mansion House, October 30, 1905.

to formulate, and with this view to proceed to the formation of a larger committee, the members of which should be chosen to represent various localities and various interests. In June a circular was issued to the members, giving some account of the proceedings of the organising committee, and defining further the aims of the guild. This published statement of aims has been sent to all invited to this meeting. In the same month it was decided that the inauguration of the Guild should take place in the autumn, and a sub-committee of three was appointed to advise with regard to all necessary arrangements. In July the report of this sub-committee was considered; the list of officers circulated to-day was taken in hand, and, among other matters dealt with, I was requested, my Lord Mayor, to ask you if you would allow the guild to be launched with becoming dignity, by consenting that the inaugural meeting should be held in this historic hall under your presidency. The organising committee is grateful for the consent you so readily accorded. They feel that you have strengthened their hands, and that under such auspices there is a hope, nay a certainty, that the guild may do for British national endeavour in the future what your ancient guilds, each in its special line of action, were founded to do in the long, long past. When my own views as to the importance, nay the burning necessity, of such a movement as this, throughout the land, among all classes, and in touch with all employments, were expressed some time ago, I suggested that it might be brought about by extending the functions of some existing organisation, such for instance as the British Association, but this, I was soon made to see, was to take an entirely too narrow view of the matter;

it was a question not merely of science and scientific men, but a question of conducting all our national activities, State services and private services, and what not, under the best possible conditions and with the greatest amount of brain power. It is not, I repeat, merely a question for scientific men; they are really not more concerned than others. Let me just refer for one moment—and I will only take one moment—to the question of education in its most general aspect. I yield to none in respect for those studies which embrace ancient civilisations and their literatures, but they alone are as incapable of forming the complete man fitted to cope with the problems presented by the world as it exists, as would be instruction in the mere facts of science apart from the actual use of the methods of observation and discovery. A complete education must be based upon things and thinking as well as upon words and memory; we want one kind of education for everybody—*the best*—and we want that education to be carried as far as is possible in the case of each individual, whether the time available for education is long or short. No one should be stopped, save by his own incapacity, from proceeding further down the fair stream of education. A perfect scheme of education should make the complete man, intellectually, morally and physically. It must not be limited merely to intellect; and we want that stream freed from the impediments with which it is at present dammed—spell the word as you will—impediments a great many of them absolutely hurtful, and most of them unnecessary from a large point of view. In a word, we want to revert to the ideal of the original university, in the curriculum of which *natura rerum* was never absent and the poor

scholar was always provided for. I will not take up your time by attempting even to sketch the tremendous reflex action such an education as this may have upon national affairs. I content myself by pointing out that the Western World is now amazed at the sudden rising of an Eastern people as a world-power, and is wondering at the efficiency of both the Navy and Army of Japan. There is really nothing to wonder at, and most of the reasons suggested for it are, I hold, entirely wrong. If the Japanese religion or the old civilisation of the country were the factors, China would have followed suit. The real reason is simply that the complete education I have sketched has been at work in Japan for thirty years, and during that time, everybody, from the Mikado to the smallest boy and girl, have been taught to think. They have been dealing with things as well as words in their schools, and they represent at the present moment the maximum of efficiency and brain power, as the result of that treatment. Mr. Chamberlain, Lord Rosebery, and others have referred to the relative advance—I may say the *great* relative advance—of the commerce and industry of Germany and the United States. Let me again point out that these are *par excellence* the lands of complete and numerous State-aided universities. Surely it is more than a coincidence that we find in those lands, the State service and all the national activities carried on in the full light of modern science, by men who have received a complete training both in science and the humanities in close touch with the Governments. If the guild helps in any way to improve our national position in this respect, it will not have been founded in vain, but there is certainly much for it to do along many lines.

THE NEW RENAISSANCE.*

(1905.)

I should like to state that when I accepted the responsibility of coming here to say a few words to you to-night, I should not have done so unless I had had a previous opportunity of examining into your methods of work, into your laboratories, into the way in which your teachers go to work, and the general lay of the land. I may say that that opportunity impressed us just as favourably as this evening has done touching the real, solid endeavour that is being made here to do that piece of work which is the most important which can be done in England at the present moment. Those of you who know what you are doing here and know what is being done in other places must feel that we are at a very interesting, almost a critical, time from an educational point of view. We may be said, indeed, to be at the beginning of a new renaissance—a new birth of learning, just in the same way that our forebears, A.D. 1000 up to A.D. 1200, were in the forefront of that first renaissance. But the trouble is that the dark ages did not cease then, for we have had a dark age since, and it is to correct this second dark age that this new birth is necessary. Now what did the inhabitants of Europe do at that first renaissance? They kept on the schools which had been brought down by the

* An address at the Borough Polytechnic Institution, December 4, 1905.

different rulers, the different church authorities, from the time of the Roman Empire. The Roman schools, judging from what the Romans did from Scotland to the south end of the Red Sea, must have dealt with the science of the time, and that perhaps is the reason that the earliest universities always included "the nature of things" in their curricula. A modern public schoolmaster might not think their education complete because Latin and Greek were the modern languages then, and the students were taught no dead ones; but, be this as it may, at the renaissance they insisted upon the teaching of Latin because then everybody who was anybody spoke Latin—it was the *lingua franca* of Europe—and not to speak Latin was to belong to the corps of the deaf and dumb. Secondly they had to learn Greek, because the movers in the educational world at that time were chiefly doctors, and they had learned all they could about doctoring and surgery from bad Latin translations of bad Arabic translations of the Greek authorities, so that when the Greek manuscripts became available all the world was agog to learn Greek in order chiefly that they might learn medicine and surgery. Now, I want to point out to you that in this we had education founded absolutely and completely upon the crying needs of the time. Very good. Then if we are going to do anything like that in our new renaissance what ought we to do if we are to follow precedent? We must arrange our education in some way in relation to the crying needs of the time. The least little dip into the history of the old universities will prick the bubble of classical education as it is presented to us to-day. Latin was not learned because it had the most magnificent grammar of known languages. Greek was not learned in

consequence of the transcendental sublimity of ancient Greek civilisation. Both these things were learned because people had to learn them to get their daily bread, either as theologians or doctors or lawyers, and while they learned them the "nature of things" was not forgotten.

Now what is the problem of to-day? We are in a world which has been entirely changed by the advent of modern science, modern nations, and modern industries, and it is therefore perfectly obvious that if we wish to do the best for our education it must be in some relation to those three great changes which have come on the world since the old days. Remember in the old days there was no experimental philosophy, there was no steam, there was little relation practically between the ordinary lives of the people and the phenomena, or, at all events, the working, of the world of nature around them. But with us all our life, the poorest life, the richest life, the country life, the town life, if it is to be lived properly and wholesomely, has to be lived in the full light of modern science; we have to know exactly the best thing to do and why we should do it. The problem before us to-day, if it be the same problem that was before those old peoples, the problem, that is to say, of learning everything we can from those around us in other nations, must drive us to the study of modern languages just as the modern world conditions drive us to modern science; so that there, I think, we have an answer to those who may ask of us: What changes are you going to make in modern education if you are going to have the best possible education? First of all, we have the fact that we are bound, if we follow precedent, to deal with those things which are of importance from the present point of view. Latin is no longer the *lingua franca* of

Europe, and we have better guides in science and philosophy than Aristotle. A question which arises when we go on to consider this matter is a very simple one: Is it worth while bothering about education? Is it worth while troubling to inquire what the old renaissance did or the new renaissance ought to do? Now there we approach a question in which the world is certainly very much wiser than it was a few years ago. Thirty or forty years ago, I am sorry to say, in this country practically nobody cared anything whatever about education, at all events about the education of the people, and the trouble with us now—the trouble that we shall have to take years to get over—is that in Germany that question was settled as early as the time of Luther, who insisted that it was the duty of all communities to look after the education of their children as well as the building of bridges and the making of roads. Now I think it is generally accepted, both in this country and in others, that whether the citizens of a State are educated or not is a matter of absolutely supreme importance—and when I say "educated" please understand that I mean educated morally and physically as well as intellectually. It is no longer merely the concern of the child or of the child's parent. It is acknowledged to be the only true foundation for a State's welfare and continued progress under conditions of peace or under conditions of war. We must face the applications of all the new sciences to every department of our much more complex national life, from the lowest employment to the highest fields of statecraft. Now you see if that is anything like true we have a great responsibility cast upon us when we talk about education. And when we inquire into the conditions we are still more

impressed by this strenuous necessity of looking the facts straight in the face and seeing how this question affects us, not merely as being in this Borough Polytechnic, but as being Britons, as being members of a civilised community in the twentieth century. I have already told you that even so far back as the time of Luther the Germans insisted that all their children should be educated; there should be no difference between the rich and the poor. What has grown out of that? The thing has gone on from strength to strength, until now in Germany, to deal with the old world, we find a country with the greatest number of universities, with the greatest possible desire, from the Kaiser down to the peasant, to do everything for Germany that can be done by educating every child that is born in the country. What did democracy do when democracy had fair play in the United States of America? The first thing done was to apportion millions of acres for the future endowment of education. The acres did not mean much capitalised then, but they mean a great deal capitalised now, so that in the Western States of America, where you get the purest-voiced democracy that you can get, I think, on the surface of the planet, the children of the citizens, boys and girls, are educated from the age of six to the age of six-and-twenty without any call upon the parents or without any hesitation to carry as many as possible up to the very highest form of education. And when does the technical instruction come in there? The technical instruction is given only to those who have taken degrees in the university. Japan is following on the same lines. The educational system of Japan was started as near as may be at the same time that the new educational policy was begun here. The result of it has been that you have

in Japan now a completely trained nation, trained to think, trained to do the best along any line that may turn up, and the difference between the existence of such a training and its opposite we have now in comparing the present condition of Japan with the present condition of China. Japan has become a world power with whom we are proud to associate simply because the Japanese children have been taught to think and to do for thirty years. That is one of the most blessed things to think of, because it shows that if any nation, even the British nation, ultimately finds that it is backward, some thirty years, or perhaps even twenty years, spent in Japanese fashion may put everything right. But if that is so, then it is my duty to point out to you that we have a great deal to do. I have said that our present system of education was commenced, roughly, some thirty years ago, when the Japanese system was started, but at present our system deals only with primary and secondary education. It is a most extraordinary thing, our Minister of Education hasn't anything to do with the most important part of education. It is a situation truly British. Well, if we find that it is necessary to imitate the action of other States in having a department which shall include the top of education as well as the bottom, it is right that I should tell you at once that this will cost a great deal of money above what we spend at present. If we take one German University, Berlin—the equivalent of the University of London—the German State spends on it the sum of £169,000 a year. That is to say, it spent that sum in the year 1891–2. Whereas for our higher educational institutions—all the universities and university colleges in England, Ireland, Scotland, and Wales—till quite recently, the

British Government allowed a smaller sum. That, I suppose, perhaps may be considered a fair estimate of the importance of education in the eyes of the British Government and in the eyes of the German Government. The worst of all this is, it is not merely a question of money and increasing taxation; it is a question of the hampering of all the industries of the country from top to bottom, from John O'Groat's to the Land's End. In an official document published by the United States Government some four years ago, it was stated, as a result of considerable inquiry, that taking the day students in the United States, in those colleges and universities where only day students were considered, there were more teachers of science in the United States than there were students of science turned out from the English colleges. Now, if that or anything like it is true, do you think that in any continued competition along any line in connection with any industry in the United States and here, that we are likely to come out top? It is absolutely impossible. Sir William Mather, more recently, has given us some information on this point. He spent four months in America looking up the technical colleges and the conditions relating to the education of the industrial classes. He found that ten years ago there were attending educational establishments, that is to say, universities and colleges, 32,000 day students; all these were taking a three years' course. To-day there are 65,000 students being educated at these same colleges, and he says the spirit of America is so completely aroused to the necessity of making science the basis of all industry, it does not matter whichever it is, however simple the undertaking, the whole tendency and trend of thought and feeling is to educate large masses

of their young men so that they may take their part, not only as managers, employers, and capitalists, but as foremen and chief workmen in their great industries, and he ends by saying that it is necessary that we should urge our Government, whether it be Liberal or Conservative, to take care that there should be sufficient expenditure provided to enable our young people throughout the length and breadth of the land to possess equal advantages to those of young people of Germany and America.

Well, then, if it is right that there should be this education conferred upon the nation, these enormous advantages, in considering the thing from the point of view either of the child or the child's parent, should there be one State-aided education for the rich and another for the poor? That is to say, if education—the *best* education—is worth all that is claimed for it, should the State deliberately foster the artificial production of a breed of second-rates? How can every child have a fair chance? Some of the older ones among you may remember Kingsley's "Saint's Tragedy." I will just quote two verses, with a little alteration in one:—

> "The same piece of clay makes a tile,
> A pitcher, a taw, or a brick;
> Dan Horace knew life—you may cut out a saint
> Or a bench from the self-same stick.
>
> "We fall on our legs in this world,
> Blind kittens tossed in neck and heels;
> 'Tis *education* that licks Nature's cubs into shape,
> She's the mill-head if we are the wheels."

Surely then, if we must not differentiate education, if we must not knowingly support second-rate education, our duty is to find the best. Well, then we come to the problem which I haven't the courage to

bring before you now, because one might talk for a week about it, and I have only twenty minutes left at the outside, even if you will grant me as much as that. What is the best education? It has taken the world a long time to find out what it already knows about it, but I doubt whether even now the world has quite got to the bottom of the problem. I think we may begin by saying that the best education should teach us to learn how to think and how to observe and how to use our hands and eyes and brain; how to exercise the body, how to become good and useful citizens, and—this is my own notion, perhaps you all will not agree to it—how to bear arms. Now, if you have such an education as that going on all over the United Kingdom, my idea is that, whatever may happen to them afterwards, whether the children become either archbishops or ploughmen, they would not be harmed by such an education, and, as a matter of fact, they could not have spent their time better. Now, that is a very important thing to bear in mind, because there are systems of so-called education about which it could be shown in a moment that those who have been put under them might have spent their time very much better. We must discriminate really very much more carefully than is generally done between education, which I will define as the power of learning how to think, and instruction, which means the accumulation of facts. Education may bring us into contact with doing things by which money may be earned, but that contact in education is used for mental training. Useful knowledge may easily become the bane of education. Instruction in doing things frankly pursued for the purpose of earning a living is generally

not so imparted that the power of thinking properly is increased and the general training carried on further. If that is anything like true, then we come to the important consideration that the best teaching must certainly include the teaching of doing things—we must not merely cultivate the memory—and, above all things, we must not stuff useful knowledge or stuff anything else into those young minds with which we have to deal. They are not Strassburg geese, and the more you attempt to stuff them the worse it will be. What we have to do is to train the mind as a delicate rapier, enabling it to do anything it has to do in the most perfect manner—to train the eye, the hands, the brain, to face anything under the best possible conditions. The question here arises, what sort of a code have we now for the education of the young?—this new code—the code for the year 1905 for elementary schools. Well, for myself, I thank God that we have such a document. It is an enormous improvement upon everything, upon anything, which has gone before it in our country. I remember some twenty years ago when the only concession made to the new knowledge was that some candidate, if he liked, might say something of what he knew about the common pump; it hardly went further than the common pump—but the new code goes very much further than the common pump, and you may even look at the stars if you like; you may even observe once or twice a year where the sun is or where the moon rises. Having this official education for the young, how are we to deal with it in relation to such an institution as yours? How are we to consider what should happen to the young minds of boys and girls going up that

educational ladder which Huxley pictured to us some years ago—that educational ladder from the gutter to the university. In considering such a ladder as this, of course the end of the teaching, the end of the time spent, in the primary school constitutes the first rung at which the educational ladder may be left, and you have to consider the certain number of boys and girls unfortunately getting off the educational ladder when they leave the elementary school. The question arises, Must everybody when they leave the primary school—and that, I am thankful to say, at a gradually increasing age—when they have done with the official education, must they have done with the instruction which will enable them better to earn their daily bread, the instruction which should, if possible, be placed before them, because really it is to tackle that instruction and to tackle the life connected with it that they have been taught to think. If you omit to give a higher education, or education combined with instruction, to your boys and girls after you have taught them to think, you have made a good deal of that education ridiculous. Your Institute proves that it is much better to give instruction to the young in things that they have to do before you make them absolutely face the music in the real contact with the stern world of reality, which they will certainly have to face sooner or later. When you consider, therefore, the stepping-off places from the education ladder—I have just referred to the first—and the necessity of getting instruction, of putting instruction in the way of those who have to step off the educational ladder, the importance, the enormous importance, of such an institution as yours begins to force itself upon one. Take the child

in an elementary school under the present regulations. Instead of going on to the secondary school and continuing still further on the elementary ladder, it can go to a higher elementary school. That is a new idea in England, and it is a very admirable one. When you ask, Why does the child step off ? you find yourself confronted chiefly with the dearness of education in this country, and then with the supposed necessity for early employment.

But nowadays the university is not an absolutely prohibited thing if those who have to do with the boys and girls concerned are keen enough to take every advantage of every opportunity; in any case employers of labour, at all events in other countries and I expect in this, begin to see the advantage of getting supplied with clerks and other assistants who have been taught to think as opposed to getting their offices crowded with people who have still to learn how to think. There are several other questions connected with the Huxley educational ladder. One is that in leaving each rung we have to acknowledge frankly that we have to face the music of the struggle for existence. Not every boy who enters a primary school can go of course to the university, can go perhaps higher than a secondary school; some will even fail to get to a secondary school, but what you have to consider, I think, generally in relation to institutions like this is that if there is to be any stepping off the ladder the change must be made in the best possible way. The present system of allowing these changes from rung to rung to take place by examination by outsiders is, I think, absolutely and completely indefensible. I would hold the teachers in

every primary school absolutely responsible for saying that such and such of their students will benefit by secondary education and some of their students will not, and if that be done then, in consequence of the recent action of the London County Council, it seems to me that you will have a rapidly-increasing number of the best English boys and girls going on with their pure education, certainly well into the secondary stage. In this way you will catch your potential Faradays. Now one of the delightful things I found in that inspection here with Mr Millis, to which I have referred, was that in all your instruction, frankly so called, you make it as educational as you possibly can, so that those who come to you at any age after the age of the primary school may, if they so choose, by taking advantage of one or other of your organisations, not only get an immense amount of absolutely needed instruction for various walks of life, but an education which will be practically as good as that which could be got on the ordinary education ladder to enable them later on to enter the universities. The recent improvements in education are brought home to us by the fact that Huxley's ladder by itself no longer represents all the present possibilities. There are now platforms at the chief stepping-off places, and ladders from them also leading to the university for those who do not fear to climb. These platforms are technical schools and institutes, in which practical training in science laboratories and literature must both find place.

There is one word I should like to say with regard to your day school. It is called a "Technical Day School for Boys." I find that in the London County

Council list, Appendix B, it is called a "secondary school." Now are you a secondary school? That is a point that I am not familiar with quite. What I understand is that under the new regulations a school to be a secondary school must make application to the Board of Education to be reckoned as such, and if it is accepted then you have this enormous advantage, or will have very shortly, if you have not it now. Your students will have the right to go to the university by passing the leaving examination, which will ultimately be carried on by the teachers in the secondary school or, at all events, by teachers associated with the secondary school. I think you will agree with me that the less any education in any locality is fettered by examination by outsiders the better for that education it will be. If you are a secondary school your students will be able as a matter of course to enter the new university. Thank God that in London, after centuries of the neglect of education, we have a university; we shall soon be as well off as a good many second-rate towns on the other side of the water have been for hundreds of years. I believe it is settled that your students can matriculate at the university, can become internal students without the bugbear of Latin, if you look upon Latin as a bugbear. Personally, I do not; if you have time to learn Latin, so much the better, but if the struggle for existence is so great that it is science or nothing with you, well with science you can new enter the London University from a secondary school. You will then carry your local students right up to the second rung, some will go on to the university, and some will step off to your evening classes. Voltaire, talking about education, said:

On étudie les livres en attendant qu'on étudie les hommes ("We study books before we have a chance of studying men"). Well, we have got past that now; we not only study books but we study things, but whether we study books or things our education will not be complete until we study men, that is to say until we have varied occasions of mingling with others who are thinking about other things, so that we may exchange thoughts and ideas and sympathies with other students of different branches of knowledge. Now I want to point out what a magnificent opportunity you have here for that kind of collegiate education. You are practically a college, and I believe strongly that this collegiate life, as we may call it, this mixing with one's fellow men, is of the very highest quality, that it is the absolute essential of a complete course of education which should produce what is called character. And let me remind you that people are prepared to pay a great deal for character. I find, for instance, that Mr. Balfour not very long ago said the collective effect of our public school education on character could not be over-rated, but he thought the boys of seventeen or eighteen who are educated in them do not care a farthing about the world they live in except so far as it concerned the cricket field, the football field, or the river. You have the machinery to enable you to care a great deal about the world you live in, to know an immense deal about it, and you have also the machinery for this formation of character. Now I believe in the combination, and it is upon that ground I hope some future day to see a strong secondary school here. I believe it will be a very great boon to this part of London, in fact, I feel so strongly on this that I should

say your enormous advantages would be wasted if you did not take some part in the general scheme of pure education, and that part is quite obvious; you have to make your day school one of the best secondary schools it is possible to imagine. I should have hesitated to give you my opinion on your proper place in education and the excellence of your teaching staff and laboratories if I had not had an opportunity of examining your institution, and, in concluding, I want again to thank Mr. Millis for his very great kindness in showing me over it the other day.

There is one little addition I should like to make to my address. I told you I hoped our British schools in time would teach boys to bear arms. Now bearing arms, to my mind, means learning simple drill and handling a rifle. I do not suppose that in the matter of the future there will be any other arms than rifles, seeing that a rifle can get rid of your adversary at a distance of 1,500 yards, which is a very safe distance indeed, so that I think we should teach all our children before they have passed the fifth standard, "fours right" and "fours left," and all that sort of thing you see people working at in the barrack yards. This would get rid of a good deal of the use of the barrack yard, and the sooner we get rid of the use the better. With regard to the rifle drill, that, I take it, can be done by having in an institution like this a little gallery, hall, or passage, or whatever you like to call it, something like 25 yards long, and the practice with the miniature rifles is so effective that I heard of a case the other day in which a sixth form boy who had been made acquainted with the handling of a rifle in this very miniature way, when his

school went down to a real butt he put six shots at 600 yards into the bull's eye out of seven. Now that is quite worth doing, and I should think it would be very interesting if you could add this drill to your excellent system of gymnastics.

APPENDICES.

(1)

The German Universities.*

What Germany thinks of the place of the university in a modern State can be readily gathered from the large and ever-increasing State endowments of the numerous universities in Prussia and the other constituent countries.

The university activity of Prussia itself dates from the time after Jena, 1806, when the nation was, as Sir Rowland Blennerhassett has told us, a bleeding and lacerated mass, so impoverished and shattered that there seemed to be little future before it. King Frederick William III. and his councillors, among them Wilhelm von Humboldt, founded the University of Berlin, "to supply the loss of territory by intellectual effort." Among the universal poverty, money was also found for the Universities of Königsberg and Breslau, and Bonn was founded in 1818. Observatories and other scientific institutions were not forgotten. As a result of this policy, carried on persistently and continuously by successive Ministers, aided by wise councillors, many of them the products of this policy, such a state of things was brought about that Palmerston, a typical English statesman, is stated by Matthew Arnold to have defined the Germany of his day as a country of "damned professors," and so well have the damned professors done their work since that not long ago M. Ferdinand Lot, one of the most distinguished educationists of France, accorded to Germany "a supremacy in science comparable to the supremacy of England at sea."

The whole history of Prussia since then constitutes indeed a magnificent object lesson on the influence of brain-power on history. There can be no question that the Prussia of to-day, the leader of a united

* *Nature*, March 12, 1903.

Germany, with its armed strength both for peace and war and craving for a wider world dominion, is the direct outcome of the policy of "intellectual effort" inaugurated in 1806.

The most remarkable thing about the German Universities in late years is the constant addition of new departments, added to enable them to meet and even to anticipate the demands made for laboratories in which each scientific subject, as it has been developed, can be taught on Liebig's plan, that is by experiment, observation and research.

It is in such State-aided institutions as these that the members of the German Ministry and Parliament, and the leading industrials are trained, while in our case, in consequence of the lack of funds for new buildings at Oxford and Cambridge, and, until not many years ago, the lack of other high-teaching centres, our leaders have had to be content with curricula extant before Galileo was born, the teaching being, perhaps, not so good and the desire to learn generally much less.

No one will deny that the brain-power of a nation must, in the last resort, depend upon the higher mental training obtainable in that nation. It is well, therefore, to see how we stand in this matter.

The following tables will show what the German Government is doing to provide brain-power in Germany. Those who know most about our British conditions will see how we are likely to fare in any competition with Germany in which brain-power comes in, if indeed there can be any important sphere of activity undertaken by either King, Lords or Commons in which brain-power does *not* come in.

We owe the first table giving the facts relating to the ordinary State endowments of the twenty-two German universities to the kindness of Mr. Alexander Siemens, who was good enough to obtain through official sources an extract from the *Preussische Statistik* containing an article by Dr. Petersilie. This deals with 1891–2, the last year dealt with by the statistical bureau.

In the second table are given the *extraordinary* expenses incurred in the same year, also obtained from Dr. Petersilie's article. There have been added the State endowments for the years 1900–1 and 1902–3, so far as it has been possible to obtain them from *Minerva*, in order that the considerable yearly increase in the endowments may be noted.

It will be seen that those responsible for the continued well-being of the German State are as busily employed in increasing the efficiency of their Universities as they are in adding to their navy.

TABLE I.—*Ordinary State Endowment, Year* 1891-2.

Universities.	Ordinary Total Income of Universities.	Sources of Income.					Expenditure.		
		Foundation Funds, Fees, &c.	State Funds.	Other Sources.	Percentage of		Salaries of Teaching Staff (including Lodging Allowance).	Various Personal Expenses.	Expenses Connected with Material.
					Foundation Funds.	State Funds.			
a. Prussian Universities.	£	£	£	£			£	£	£
1. Berlin	123,839	16,782	107,057	—	14	86	44,504	23,769	55,565
2. Bonn	56,467	10,661	45,806	—	19	81	24,404	8,334	23,729
3. Breslau	48,203	3,454	44,749	—	7	93	21,845	7,927	18,430
4. Göttingen	57,363	36,487	20,877	—	64	36	24,601	10,248	22,512
5. Greifswald	35,807	21,833	13,974	—	61	39	14,605	5,870	15,332
6. Halle	62,880	29,596	33,284	—	47	53	20,791	9,015	33,073
7. Kiel	37,722	9,584	28,188	—	25	75	13,471	5,682	18,618
8. Königsberg	46,405	6,475	39,930	—	14	86	17,193	7,374	21,836
9. Marburg	38,872	8,743	30,129	—	22	78	15,068	6,732	17,070
10. Munster Academy	12,312	4,202	8,110	—	34	66	8,000	1,737	2,574
11. Braunsberg Lyceum	2,040	1,046	994	—	51	49	1,741	82	216
Prussian Universities altogether	521,910	148,863	373,098	—	33	67	206,223	86,770	228,955

TABLE I.—*Continued.*

Universities.	Ordinary Total Income of Universities.	Sources of Income.					Expenditure.		
		Foundation Funds, Fees, &c.	State Funds.	Other Sources.	Percentage of		Salaries of Teaching Staff (including Lodging Allowance).	Various Personal Expenses.	Expenses Connected with Material.
					Foundation Funds.	State Funds.			
b. Other than Prussian Universities.	£	£	£	£			£	£	£
1. Munich	45,678	13,069	32,609	—	29	71	24,669	10,981	10,028
2. Wurzburg	36,246	15,707	20,539	—	43	57	14,099	11,316	10,831
3. Erlangen	31,722	6,813	24,909	—	21	79	11,591	10,149	9,982
4. Leipzig	99,373	21,439	77,934	—	22	78	27,162	43,917	28,293
5. Tubingen	44,068	5,309	38,759	—	12	88	13,669	12,602	17,798
6. Freiburg	25,984	3,996	21,893	95	16	84	13,021	3,538	9,424
7. Heidelberg	34,949	987	33,895	67	3	97	16,569	3,541	14,839
8. Giessen	32,749	9,530	23,178	41	29	71	11,988	2,358	18,402
9. Rostock	16,614	113	16,290	211	2	98	7,722	795	8,097
10. Jena	—	—	—	—	—	—	—	—	—
11. Strassburg	49,750	3,917	45,575	257	8	92	26,300	3,611	19,838
Non-Prussian Universities altogether, excluding Jena	417,133	80,880	335,581	671	19	81	166,790	102,808	147,532
Prussian Universities	521,911	148,863	373,098	—	33	67	206,223	86,770	228,955
All the German Universities, excluding Jena	939,044	229,743	708,679	671	26	74	371,013	189,578	376,487

TABLE II.—*Showing Extraordinary Expenditure 1891–2, and Increase of Ordinary Endowment since then.*

Universities.	Ordinary State Endowment, 1891–2.	Extraordinary Expenditure Provided by the State in 1891–2.	Ordinary State Endowment, 1900–1.	Ordinary State Endowment, 1902–3.	Increase of Ordinary State Endowment in 11 years (in thousands).
	£	£	£	£	£
a. Prussian Universities.					
1. Berlin	107,057	61,714	130,743	142,155	35
2. Bonn	45,806	9,690	51,982	56,091	11
3. Breslau	44,749	38,900	57,435	57,435	13
4. Göttingen	20,877	6,260	27,403	30,414	10
5. Griefswald	13,974	5,762	20,490	23,925	10
6. Halle	33,284	15,919	51,666	54,419	21
7. Kiel	28,188	5,690	37,286	41,891	13
8. Königsberg	39,930	12,350	47,069	50,936	11
9. Marburg	30,129	2,660	36,255	38,931	8
10. Munster Academy	8,110	300	14,364	18,242	10
11. Braunsberg Lyceum	994	—	1,989	2,990	2
Prussian Universities; totals	373,098	159,245	476,682	517,429	144
b. Other than Prussian Universities.					
1. Munich	32,609	13,932	—	—	—
2. Wurzburg	20,539	375	—	—	—
3. Erlangen	24,909	3,766	—	—	27
4. Leipzig	77,934	—	101,989	104,388	14
5. Tubingen	38,759	—	49,703	52,234	9
6. Freiburg	21,893	7,825	28,555	30,955	8
7. Heidelberg	33,895	14,771	39,125	41,225	19
8. Giessen	23,178	6,990	37,480	42,188	—
9. Rostock	16,290	—	17,812	—	—
10. Jena	—	—	—	—	—
11. Strassburg	45,575	12,440	49,150	49,862	—
Non-Prussian Universities; totals	335,581	60,099	323,814	320,852	

In Britain there is no concern shown by our Government and politicians in regard to the *real* sources of *national* brain-power, towards which primary instruction, now well endowed, is but the first step. Private endowment is still appealed to, though our present unfortunate position comes from the fact that since the necessary introduction of science into the curriculum of the higher teaching, private endowment in the past has not been, nor in the future will it be, able to supply a tithe of what is really wanted.

(2)

THE UNIVERSITIES OF THE UNITED STATES.*

Any consideration of what the nation has done for higher education in the United States must be prefaced by a reference to two laws passed in 1787 and 1862 respectively. The first Act, enacted for the Government of the territory north of the Ohio, provided that not more than two complete townships† were to be given to each State perpetually for the purposes of a "University to be applied to the intended object by the legislature of the State." In 1862 an Act was passed giving to each State 30,000 acres of land for each senator and representative to which the State was then entitled, for the purpose of founding "at least one college, where the leading object shall be, without excluding other scientific and practical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States shall respectively prescribe, in order to promote the liberal education of the industrial classes in the several pursuits and professions of life."‡

A reference to Table i. below, showing the number of acres of land in each of the States, the income, accruing from which is available for University education, demonstrates more conclusively than any words could do how very fully advantage has been taken throughout the United States of the legislative enactments of 1787 and 1862. The table is due to Dr. Frank W. Blackmar, and is contained in "The History of Federal and State Aid to Higher Education in the United States," published in Washington in 1890.

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* *Nature*, May 14, 1903.

† In surveys of the public land of the United States, a division of territory six miles square, containing thirty-six sections.

‡ "Report of the Commissioner of Education for the Year 1896–7." Vol. ii., p. 1145. (Washington, 1898.)

TABLE I.—*Land Grants and Reservations for Universities.*

States and Territories.	Acres.	Dates of Grant.
Ohio	69,120	1792, 1803
Indiana	46,080	1816, 1804
Illinois	46,080	1804, 1818
Missouri	46,080	1818, 1820
Alabama	46,080	1818, 1819
Mississippi	46,080	1803, 1819
Louisiana	46,080	1806, 1811, 1827
Michigan	46,080	1836
Arkansas	46,080	1836
Florida	92,160	1845
Iowa	46,080	1845
Wisconsin	92,160	1846, 1854
California	46,080	1853
Minnesota	82,640	1861, 1857, 1870
Oregon	46,080	1859, 1861
Kansas	46,080	1861
Nevada	46,080	1866
Nebraska	46,080	1864
Colorado	46,080	1875
Washington	46,080	1854, 1864
North Dakota, South Dakota	46,080	1881
Montana	46,080	1881
Arizona Territory	46,080	1881
Idaho Territory	46,080	1881
Wyoming Territory	46,080	1881
New Mexico Territory	46,080	1854
Utah Territory	46,080	1855
Total	1,395,920	

The grant of 1862 proved insufficient, and in 1890 an Act for the "more complete endowment of the institutions called into being or endowed by the Act of 1862" was passed.

But these land grants do not exhaust the means adopted by the State to encourage higher education in the United States. In the book to which reference has been made, Dr. Blackmar summarises the principal ways in which the several States have aided higher education. They are as follows:—

(1) By granting charters with privileges.

(2) By freeing officers and students of colleges and Universities from military duties.

(3) By exempting the persons and properties of the officers and students from taxation.

(4) By granting land endowments.

(5) By granting permanent money endowments by statute law.

(6) By making special appropriations from funds raised by taxation.

(7) By granting the benefits of lotteries.

(8) By special gifts of buildings and sites.

The result is, as Prof. Edward Delavan Perry, of Columbia University, has said,* "At the present time, in each of the twenty-nine of the States of the Union, there is maintained a single 'State University' supported exclusively or prevailingly from public funds, and managed under the more or less direct control of the legislature and administrative officers of the State. These States are the following:—Alabama, California, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, North Carolina, North Dakota, Ohio, Oregon, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin and Wyoming.

"The universal verdict of public opinion in the States where such institutions are maintained is that they, as State organisations supported directly by public taxation from which no taxable individual is exempt, should be open without distinction of sex, colour, or religion to all who can profit by the instruction therein given."

The figures necessary to express how much university education in the United States owes to the American Government are large, and the total amount of the aid is enormous. The following table, drawn up with the assistance of the report of the United States Commissioner of Education for the year 1899–1900, will enable the reader to form some idea of the splendid resources placed at the command of American Universities. The grand totals under each heading will be found in Tables v. and vi., so arranged as to show the proportion of each total available for the University education of women.

The universities and colleges of the United States have another source of income in addition to the generous provision made by the State. Every year wealthy American citizens place large sums of money at the disposal of the educational authorities for the purposes of higher education and the encouragement of scientific research. During the eleven years 1890–1901, the amount of these donations reached

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* See Prof. Nicholas Murray Butler's monographs on "Education in the United States," vol. i.

TABLE II.—*Statistics showing Value, Endowments, Appropriations, Income and Benefactions of Universities and Colleges in the United States in* 1899–1900.

State or Territory.	Value of Libraries, Apparatus, Grounds and Buildings.	Value of Endowments—Productive Funds.	Tuition and other Fees.	Income from Productive Funds.	State, Municipal and U.S. Government Appropriations.	Income from other Sources.	Total Income.	Benefactions.
	£	£	£	£	£	£	£	£
Maine	351,200	377,900	17,600	17,500	14,000	3,000	52,100	13,900
New Hampshire	220,600	460,000	8,900	12,000	2,000	0	22,900	70,000
Vermont	198,700	165,000	3,600	9,100	8,100	1,500	22,300	28,700
Massachusetts	3,084,800	4,083,000	292,500	179,300	0	50,000	521,800	257,600
Rhode Island	301,700	259,400	19,400	15,700	0	300	35,400	30,400
Connecticut	1,577,800	1,414,300	106,900	69,700	0	5,700	182,300	156,400
New York	5,846,400	5,681,500	289,000	257,400	48,300	111,000	705,700	363,300
New Jersey	983,300	563,300	39,600	26,700	8,000	0	74,300	47,200
Pennsylvania	3,075,600	2,381,800	217,000	95,000	43,500	34,600	390,100	170,500
Delaware	34,000	16,600	300	1,000	8,000	600	9,900	—
Maryland	784,000	754,400	54,800	19,700	19,000	11,600	105,100	13,000
Columbia	974,900	279,400	34,300	14,700	20,600	14,700	14,300	14,600
Virginia	753,000	392,600	48,200	20,500	12,800	9,400	90,900	16,400
West Virginia	119,700	33,900	4,100	1,800	28,700	3,600	38,200	10,200
North Carolina	484,500	179,000	38,100	10,101	5,000	11,500	64,700	17,700
South Carolina	303,400	123,800	23,700	6,800	5,900	7,800	44,200	30,400
Georgia	491,600	184,400	37,900	11,400	5,400	8,600	63,300	20,700
Florida	104,800	85,100	4,500	5,400	4,500	0	14,400	3,500
Kentucky	437,100	332,400	33,700	17,000	13,400	9,800	73,900	27,500
Tennessee	992,000	527,000	70,200	26,900	12,700	33,700	143,500	58,800
Alabama	325,800	70,000	20,300	2,400	2,500	6,000	31,200	2,100
Mississippi	233,000	180,300	23,800	8,300	12,900	8,000	53,000	200
Louisiana	436,300	387,900	18,800	25,000	8,600	1,700	54,100	3,000
Texas	444,600	143,900	46,000	7,600	15,600	21,000	90,200	20,100
Arkansas	133,300	33,000	10,000	2,400	13,300	1,600	27,300	3,900

TABLE II.—*Continued.*

State or Territory.	Value of Libraries, Apparatus, Grounds and Buildings.	Value of Endowments—Productive Funds.	Tuition and other Fees.	Income from Productive Funds.	State, Municipal and U.S. Government Appropriations.	Income from other Sources.	Total Income.	Benefactions.
	£	£	£	£	£	£	£	£
Oklahoma	14,600	—	200	0	3,800	0	4,000	—
Indian Territory	13,500	200	1,200	0	0	1,000	2,000	1,800
Ohio	2,114,900	1,901,500	91,200	84,700	64,400	26,300	266,600	133,600
Indiana	867,200	431,100	30,900	23,000	17,500	5,200	76,600	12,300
Illinois	2,256,000	2,310,500	199,400	96,800	61,500	31,100	388,800	386,900
Michigan	678,800	374,600	50,000	19,300	58,700	10,600	138,600	56,800
Wisconsin	627,300	334,000	22,800	15,300	62,800	4,500	105,400	10,400
Minnesota	627,100	332,700	35,200	15,400	35,100	8,900	94,600	15,200
Iowa	632,500	300,800	48,400	18,900	15,000	31,600	113,900	51,600
Missouri	1,359,800	737,300	77,200	33,800	14,900	19,600	145,500	67,400
North Dakota	47,700	8,000	1,000	600	9,100	0	10,700	4,800
South Dakota	92,400	20,000	4,610	800	6,600	1,100	13,100	19,200
Nebraska	451,300	67,300	13,700	3,800	46,400	4,400	68,300	9,400
Kansas	624,900	84,000	33,900	5,300	24,000	18,500	81,700	23,500
Montana	43,700	—	1,900	2,000	4,300	0	8,200	—
Wyoming	43,300	1,400	100	0	1,000	100	11,200	0
Colorado	343,300	124,000	8,000	7,400	14,400	2,200	32,000	46,600
New Mexico	16,500	—	100	0	2,200	0	2,300	2,700
Arizona	30,900	—	—	0	10,000	500	10,500	—
Utah	126,900	51,400	2,900	1,300	12,300	2,900	19,400	800
Nevada	50,400	—	—	—	11,400	0	11,400	—
Idaho	49,900	—	0	0	10,000	0	10,000	0
Washington	269,600	37,700	11,000	2,500	10,000	500	24,000	45,500
Oregon	124,900	89,000	5,200	4,400	6,000	900	16,500	5,600
California	1,376,000	4,250,200	41,100	78,500	55,300	3,500	178,400	11,300

the grand total of nearly 23,000,000*l.*, as Table III., compiled by Prof. Nicholas Murray Butler, shows :—

TABLE III.—*Total amount of Benefactions* * *to Higher Education in the United States.*

Reported in	£	Reported in	£
1890–91	1,515,018	1896–97	1,678,187
1891–92	1,336,917	1897–98	1,640,856
1892–93	1,343,027	1898–99	4,385,087
1893–94	1,890,101	1899–1900	2,399,092
1894–95	1,199,645	1900–01	3,608,082
1895–96	1,810,021		

From 1871–1890, the total amount of benefactions for education of the kind with which this article is concerned was, the annual reports of the United States Bureau of Education show, 16,285,000*l.*, so that for the years 1871–1901, the grand total of 40,000,000*l.* sterling was raised by private effort for American University education.

The question naturally presents itself, What has been done by private effort in this country to assist University education during the same period ? Compared with American munificence, the amounts given and bequeathed here are very small. Take in the first place the University Colleges, which are largely to be regarded as a growth of the years under consideration. The financial statements contained in the "Reports from University Colleges, 1901," published by the Board of Education, reveal the fact that, including the 400,000*l.* raised for the University of Birmingham, the benefactions to the fifteen University Colleges in Great Britain amounted during 1870–1900 to a little more than £3,000,000. In the absence of systematic reports during the same period of the financial resources of the older Universities of the United Kingdom, it is difficult to estimate the amount of benefactions received by them during the same thirty years. The parliamentary returns which have been published since 1898, showing the revenue of Scottish Universities, suggest that their benefactions in the same time, excluding Mr. Carnegie's splendid gift, may be put at something under £500,000, so that for the whole of the United Kingdom the total amount of endowment from private sources raised in these years may, without any risk of under-estimation, be said to be considerably less than £5,000,000.

To give some idea of the result of the broad-minded policy of the legislatures of the several States and of the treatment which higher

* Compiled by Prof. Nicholas Murray Butler, Columbia University, and published in "Special Reports on Educational Subjects," vol. xi., part ii.

education has received at the hands of American statesmen and men of wealth, the following short summaries have been drawn up, with the assistance of the Report of the Commissioner of Education of the United States Bureau at Washington, published in 1901, for the year 1899–1900. The first (Table IV.), shows the number of colleges having endowments

TABLE IV.—*Classification of Colleges and Universities for Men and for both Sexes, according to Amount of Endowment Fund.*

£		£	
20,000	to	40,000	56
40,000	,,	60,000	38
60,000	,,	80,000	13
80,000	,,	100,000	14
100,000	,,	120,000	7
120,000	,,	140,000	4
140,000	,,	160,000	5
160,000	,,	180,000	2
180,000	,,	200,000	1
200,000	,,	250,000	8
250,000	,,	300,000	5
300,000	,,	400,000	3
400,000	,,	600,000	4
600,000	,,	800,000	4
800,000	,,	1,000,000	1
1,000,000	,,	1,500,000	2
1,500,000	,,	2,000,000	—
		Over 2,000,000	3

of certain specified amounts. The second summary (Table V.), shows the total property of all American university colleges, tabulated under the headings of fellowships and scholarships; values of libraries, apparatus, grounds and buildings; and of their productive funds. The next (Table VI.), shows the amounts of income of these colleges, and the last (Table VII.), gives the total number of professors, instructors and students in colleges of university standing.

It is interesting in this connection to compare the number of students taking university courses in this country with those in Germany and the United States. With this object in view, Table VIII. has been prepared, but it should be pointed out that the number of students in our university colleges includes all above the age of sixteen, which is probably much lower than the age of these students included in the totals for other countries. It is well to remember, too, that the number of American university students is probably too high for a fair comparison with those of Germany. Many university students in the United States are really students in higher branches of technology, and would in Germany study in technical high schools, the students of which are not included in Germany's total in the table. To make the

TABLE V.—*Property of Universities and Colleges in the United States* (1899–1900).

Description of Institution.	Number of fellowships.	Number of scholarships.	Value of libraries.	Value of scientific apparatus.	Value of grounds and buildings.	Productive funds.
			£	£	£	£
For men and for both sexes	476	7,619	2,138,000	3,027,000	27,267,000	29,478,000
For women - - - -	18	447	132,000	157,000	3,129,000	1,088,000

TABLE VI.—*Income of Universities and Colleges in the United States* (1899–1900).

Description of Institutions.	Fees.	From productive funds.	State or muncipal appropriations.	From United States Government.	From other sources.	Total Income.	Benefactions.
	£	£	£	£	£	£	£
For men and for both sexes	1,675,000	1,222,000	691,900	197,000	393,000	4,179,000	2,168,000
For women - - - -	468,000	57,000	7,000	—	136,000	670,000	118,000

comparisons as simple as possible the number of university students per 10,000 of population has been calculated.

TABLE VII.—*Professors, Instructors and Students in Universities and Colleges of United States.*

Institutions.	Professors and Instructors.*	
	Men.	Women.
For men and for both sexes (480 institutions) - - - - -	12,664	1,816
For women (141 institutions) - -	697	1,744
	Students.	
	Men.	Women.
Total number of students in Universities and colleges - - - -	61,800	35,300

TABLE VIII.—*Number of University Students per* 10,000 *of Population* (1900).

Country.	Population.	Number of Students.			Number of Students per 10,000 of population.
			Day.	Evening	
United Kingdom - -	41,164,000	Universities	12,000		4·98†
		University Colleges	8,500	5,000	
German Empire - - -	56,367,000	44,400			7·87
United States - - -	76,086,000	97,100			12·76

The statistics provided above make it possible to form a good estimate of the comparative amounts of importance attached to higher education in this country and in the United States. Table VI. shows that, neglecting the income accruing from the State land grants, the legislatures of individual States and the United States Government together supplied about 900,000*l*. for university education during 1899–1900,

* Excluding duplicates.

† Excluding evening students of University Colleges.

while the article in NATURE for March 12, 1903, shows that the total State aid to universities and colleges in the United Kingdom at present amounts only to 155,600*l*. Table VI. also brings out another important principle; it reveals the fact that during 1899–1900 private effort provided more than two and a quarter millions sterling for the colleges of the United States, and thus leads to the conclusion, which is strengthened by Table III., that interest on the part of the State in higher education leads to a corresponding enthusiasm among men of wealth.

A comparative study of this kind is of vital national interest; our very existence as a nation depends directly upon success in that industrial warfare between the great countries of the world from which there can be no peace. The last article in this series has shown the great importance attached by German statesmen to the higher education of the directors of German industries, and how greatly superior is the provision made for this purpose in Germany to that in this country. A similar conclusion is reached by studying the subject from the American point of view; we are equally behind the United States. Unless our Government, on one hand, and our men of wealth on the other, take immediate steps, and make serious efforts to remedy these deficiencies in our higher education, British manufacturers cannot hope to hold their own successfully with either German or American competitors. The amount by which we fall short of the United States, the deficiency which must be made good simply to bring us level with America in the race for industrial supremacy, will be seen from the following deductions from the above statistics :—

(1). The amount raised during 1871–1901 by private munificence for higher education was, in the United States, more than eight times that similarly provided in the United Kingdom.

(2). In addition to the large income from State land grants, the amount provided by the State for higher education is, in the United States, six times as much as the Government grant for the same purpose in the United Kingdom, where there is nothing corresponding to the land grants.

(3). In the United States there are 170 colleges with an endowment of more than 20,000*l*.; forty-nine of these have endowments of more than 100,000*l*., and three of more than two millions sterling. In the United Kingdom there are thirteen universities and twenty other university colleges. Four of the universities do little more than examine.

(4). In the United States nearly thirteen of every 10,000 inhabitants are studying during the day at colleges of university status; the number in the United Kingdom is less than five.

(5). The value of the endowments of institutions of higher education in the single State of New York exceeds the total amount of benefactions

for similar purposes raised during thirty years in the whole of the United Kingdom. The same is nearly true in the States of Massachusetts and of California.

(6). The number of *professors and instructors* at the Universities and colleges included in the list of the United States Commissioner of Education is 17,000. The number of *day students* in our Universities and University Colleges is only about 20,500, so that there are almost as many University *teachers* in the United States as there are University *students* in the United Kingdom!

A careful study of the tables here brought together will do more than anything else to explain the success which has attended American manufactures and commerce in recent years. America has learnt that to energy and enterprise must be added trained intellect and a familiarity with recent advances in science. Other things being equal, that nation will be most successful in the competition for the markets of the world which makes the most generous provision for the higher education of its people.

(3)

The Requirements of the University of Birmingham.*

Among the many documents prepared by Principal Sir Oliver Lodge in relation to the development of the University of Birmingham, there are more than one of which the interest is by no means merely local. Of these, the pamphlet entitled "Survey of the Sciences," which forms an appendix to a paper on University Development, is of especial importance at the present time, for we are glad to know that the belief that the weakness of our Universities must lead to national weakness in several directions is growing with a rapidly accelerating pace.

It may be long in this slow-moving country before the influence of brain-power on history is recognised as fully as the influence of sea-power has been, thanks to Captain Mahan, but undoubtedly it will be bad for our future if much more time is lost.

The paper on the "Survey of the Sciences" begins as follows:—

"In a recent pamphlet I considered the question of the relation of the University of Birmingham to its central and suburban sites, with a view of determining what recommendations should be made to the Council concerning the Departments which ought to migrate and the Departments which ought to remain. I was able to arrive at some judgment on the matter except in connection with the Faculty of Science,

* *Nature*, January 1, 1903.

and there the problem became so complicated that it was necessary to make a survey of the sciences in order to get the material on which to form an opinion. This survey is now printed, not only as an appendix to the former paper, but because it is hoped that it may be useful for other purposes; especially I hope that it may be of interest to those who are able to help financially in the forthcoming great educational development of the future, enabling them to realise the immensity of the area which we attempt to cover, and the largeness of the sum which could be properly invested in suitable buildings and equipment and in endowment of staff. Our position is such that if some man of power thought fit to exercise it by entrusting us with a sum of 5,000,000*l.* for University development, it could be well and properly employed; nor could such an investment fail to exercise an extraordinary influence on the progress of the country. Hitherto the ideas of this country in education and scientific research have been conceived on a wholly inadequate scale, and without proper appreciation of the vast extent of territory over which a modern University is called upon to preside."

After referring to the sciences already dealt with at Birmingham and the collateral branches and practical applications, the pamphlet concludes as follows:—

"In venturing to name such a sum as £5,000,000, I have had in view certain considerations which it may be well to set forth.

"First, it has been found that the Carnegie donation to Scottish universities is insufficient to attain its objects, and already it appears likely that it may have to be doubled.

"Next, it is well-known, and indeed painfully familiar to all who have to do with administration, that every new department started, and every new building erected, means an increase of current expenditure and a drain upon resources. Expenditure is called for on behalf of rates, portering and cleaning, heating and lighting, maintenance, depreciation and supersession of equipment, and materials for experiments and processes. There are also annual grants to be made to the library, to the various laboratories and museums, and to departmental libraries. Then there is a large disbursement for salaries of demonstrators and curators and assistance and technical instructors. All these expenses come out of revenue, and are probably best provided for by the income derived from fees, and from the contemporary support of county and other bodies, so as to preserve dependence on the interest of the living generation. But it is highly desirable to keep fees low—not by any means to abolish them, but to keep them low—so as to bring higher education within reach of all who are able to make use of it: a number which, with the improvement of schools, will probably be

rapidly increasing. Hence it is probable that the above-mentioned items of annual expenditure will absorb the whole of the ordinary annual income and leave nothing for the payment of the chief professors and lecturers. Everywhere it has been found essential that chairs shall be endowed, so as to put them on a permanent and substantial basis; moreover it is vitally important to be able to attract the best men, wherever they are to be found. At the present time it is not usually possible to compete with other places for the best men unless we can offer a sum comparable to £1,000 a year, and in some subjects more.

"An invested million will therefore on the average relieve the annual income of the stipends for thirty principal chairs. There must be a large number of lectureships, or subsidiary and supplemental chairs, and sixty of these at £500 each could be provided with the second million.

"The buildings already in progress on the new site are to cost more than a quarter of a million, and the remainder of what has been sketched out and actually contemplated will cost the other three-quarters. Another half a million at least will be needed to equip them properly.

"The older or central site will also need considerable enlargement and fresh buildings should rise there. Half a million may be set aside for ultimate building and equipment on and near the Mason College site.

"Four out of the five millions are thus accounted for; the fifth is intended for a real attempt at scientific research in all departments. A fund by which men could be sent to any part of the world: to study tropical diseases, or fisheries, or mining possibilities—to investigate either nascent industries or injured industries of any kind; a fund which could equip research laboratories at home, and could defray the expense of researches undertaken on a large or engineering scale, so as to bring in rapidly some practical results. At present there are men who perceive how many things could be reformed or improved, whether n purification of the atmosphere, or in novel modes of locomotion, or in many other ways; but they lack the means to demonstrate their plans or to try experiments. Manufacturers and municipalities sometimes try experiments on a very extensive scale indeed—a really commercial scale—and in case of failure the resulting experience is over-dear. The endowment would not allow experiments on such a scale as that; considering the variety of subject, the amount available for each would permit of no extravagance. Some of the experiments undertaken would undoubtedly fail, yet the success of a few would far more than compensate for the failure of many, and the activity could not but conduce to progress.

"The fund would have to provide not only the necessary appliances and assistance, but it would endow fellowships for post-graduate study

and would attract workers from many parts of the world, and certainly from the Colonies.

"One Principal could not possibly supervise all the multifarious activities which we have thus supposed may some day be called into being. There would have to be a Research Principal (whatever he might be called), to organise and superintend the scientific and post-graduate study; a Technical Director, in touch with all the technical departments; and an Educational or General Head, to supervise the general scheme of the college in all its various avenues to a degree, and to take a lead in whatever conduced to general culture.

"If the scheme is lavish it represents lavishness in the right place. It is the kind of lavishness for which the nation is waiting—one of the few kinds of which hitherto it has been afraid.

"'There is that scattereth but yet increaseth;
There is that withholdeth more than is meet, but
it tendeth to poverty.'

"These lines refer not to individual wealth alone, but to national wealth also. We have failed to make the most hitherto of the brains and energy of our more able and specially-gifted youth, but have cramped them by the necessity of earning a living: a process wholesome enough for the individual, and right for 999 out of every thousand, but for the remaining one far less repaying to the Commonwealth than the special service which he could render, if set free and encouraged by suitable surroundings for a few years of research, following on a thorough educational preparation. Not all of these would justify their selection: nine-tenths of them even might do only moderately well; but the discoveries of the select tenth would be of incalculable value. The world has been wasteful of its genius hitherto. It thinks too facilely that people exceptionally endowed will struggle to the front somehow. A few do, but a number do not; the conditions are not favourable; and the struggle for existence, though doubtless a stimulating training for the hardier and sturdy virtues, is not the right atmosphere for the delicate plant called genius. Different kinds of treatment are suited to different characters, and the hot-house plant will not thrive in bracing arctic air.

"From the trust deed with which Mr. Carnegie has endowed a research institution at Washington with 10,000,000 dollars, I extract the following altogether admirable statement of '*aims*':—

"'1.—To promote original research: paying great attention thereto, as one of the most important of all departments.

"'2.—To discover the exceptional man in every department of study, whenever and wherever found, inside or outside of schools;

and to enable him to make the work for which he seems specially designed his life-work.

" '6.—To ensure the prompt publication and distribution of the results of scientific investigation; a field considered highly important. . . . " 'The chief purpose of the founder being to secure if possible, for the United States of America leadership in the domain of discovery, and the utilisation of new forces for the benefit of man.' "

(4)

The Requirements of the Welsh University and Colleges.*

We saw that the great bulk of the endowments of the German universities was provided by the State, 81 per cent. of the total being so provided in Prussia, and 74 per cent. in Germany as a whole. Wales, happily or unhappily, possesses comparatively few men whose individual possessions could enable them to take part in endowing her colleges in any way commensurate with the need. Of the sums that have been raised for buildings, a great part has been collected, at the cost of healthy but disproportionate effort, from the shillings and pence of artisans and small farmers or traders. It is not surprising, therefore, to find that the colleges and the university depend already mainly upon public funds. The county council grants to Cardiff and Aberystwyth must in fairness be counted as fees, not endowments, since they are given in return for teaching a definite class of students, and a change of policy in the local authorities might at any time modify or even divert their contributions. The figures are approximately† as follows, reckoning the interest on investments, as heretofore, at $2\frac{1}{2}$ per cent., and including in the Government grants those devoted to special objects, such as agriculture, and the training of primary teachers.

Present Endowment of University Education in Wales.

	Income from Private Endowments.	Income from Government Grants.
	£	£
University College, Aberystwyth	375	6,000
University College, Bangor	1,225	6,000
University College, Cardiff	750‡	5,250
The University of Wales	—	4,000
Totals	£2,350	£21,250
Percentages	10	90

* *Nature*, July 16, 1903.

† The exact figures vary slightly from year to year.

‡ Including the annual grant of £350 from the Drapers' Company for engineering.

There is only one conclusion. In great cities like Liverpool and Manchester there is accumulated wealth and an accumulated tradition of culture to which their colleges have appealed with some success. In Wales the culture has been for centuries remote from university life, and the wealth, as we have seen, is non-existent. If, therefore, the Government wishes that the £21,000 a year which it now spends in grants to the colleges and the University of Wales shall not be wasted, it is high time that it should face the question of what they really need.

In order to represent these needs in as concrete a form as possible, we have made inquiries as to the sums which, in the opinion of responsible persons at each college, would suffice to place them in a position to discharge their work with real efficiency. In each case we shall mention two capital sums, the one that required to construct or complete the buildings and equipment of the college, the other that required as an endowment for maintenance, the interest in this latter case being reckoned at 2½ per cent. Aberystwyth has from the first been the most fortunate of the three colleges in the matter of buildings, so that its needs under this head are smaller; similarly Bangor needs slightly less towards maintenance as being possessed of somewhat larger invested endowments, Cardiff and Aberystwyth having only very small possessions of this kind; trust-funds for scholarships are, of course, disregarded altogether in the estimate.

The figures assume that the present Government grants will continue, and under both heads state the sums needed in addition to all the resources the colleges at present possess.

Funds needed for University Education in Wales.

	A. For Buildings and equipment.	B. For Endowment.
	£	£
University College, Aberystwyth -	99,800	1,071,500
University College, Bangor - -	176,500	960,400
University College, Cardiff - -	162,000	1,176,400
The University of Wales - - -	—	288,400
Totals - - - - - - -	£438,300	£3,496,700
Grand Total - - - - -	£3,935,000	

In round figures, therefore, we may say that university education in Wales needs an endowment of £4,000,000 sterling to secure its

efficiency. This will not be thought an extravagant figure when it is remembered that the need of the Birmingham University was estimated at £5,000,000, and that the Welsh colleges minister to the needs of a far more diverse population. The agriculture, the manufactures, the mining and the over-sea commerce of Wales all demand the enlightenment and intelligence which can only be developed in universities efficiently equipped for their work.

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